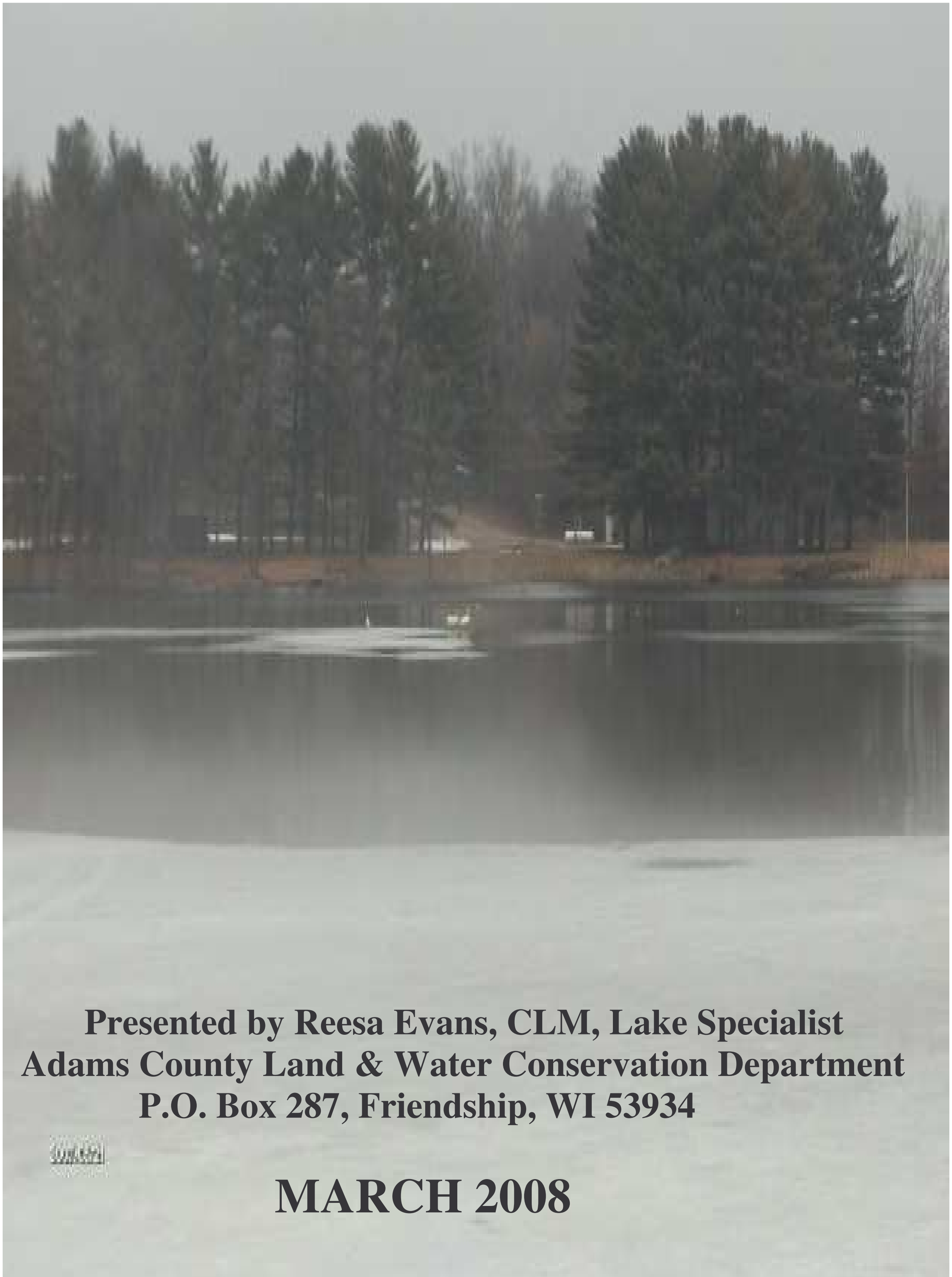
ARKDALE LAKE
LAKE CLASSIFICATION REPORT



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ARKDALE LAKE LAKE CLASSIFICATION REPORT

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EXECUTIVE SUMMARY

Background Information about Arkdale Lake

Arkdale Lake is located in Adams County in south central Wisconsin and is a 47-acre impoundment (man-made) lake located in Strongs Prairie, Adams County, in the Central Sand Plains Area of Wisconsin. This lake is formed by an impoundment of Big Roche a Cri Creek and is downstream from another impoundment, Big Roche a Cri Lake. Big Roche a Cri Creek ultimately empties into the Wisconsin River. Arkdale Lake is part of the Big Roche a Cri Creek watershed, which covers 177 square miles and extends into the next county east of Adams. Arkdale Lake has two public boat ramps, both of which are small and shallow. There are several Native American archeological and American historical sites located in the Arkdale Lake watersheds that cannot be further disturbed without permission of the federal government an/or input from the local tribes.

Except for some pockets of muck and silt loam, the soils in the surface and ground watersheds for Arkdale Lake are loamy sand and sand, with slopes ranging from very flat up to steep. Water, air and nutrients move through these soils at a rapid rate, so little runoff occurs unless the soil becomes saturated. Wind erosion, water erosion and drought are common hazards of these soil types.

Land Use in Arkdale Lake Watersheds

Although the surface watershed of Arkdale Lake is small, the ground watershed is very large (over 20,000 acres). In addition, Arkdale Lake receives input from the upstream Big Roche a Cri Creek watershed. In the surface watershed, the two most common current land uses in the Arkdale Lake watersheds are woodlands and non-irrigated agriculture. In the ground watershed, woodlands dominate the land use. The east entry into Arkdale Lake is the stream winding through several wetland areas that serve as filters. Wetlands play several important roles in maintaining water quality, in the aquatic food chain and in wildlife nesting. It is essential to preserve these wetlands for the health of Arkdale Lake.

Arkdale Lake has a total shoreline of 4.1 miles (21,648 feet feet). Most of the shore consists of privately-owned lots. The two public boat ramp areas are located on the north and south sides of the lake. On some of the lake, areas immediately at the shore are steeply sloped. Buildings are generally located 70 or more feet back from the shore on the south side of the lake, but several are closer on the north side of the lake.

A 2004 inventory classified shorelines has having “adequate” or “inadequate” buffers. An “adequate” buffer was defined as one having the first 35 feet landward covered by native vegetation. An “inadequate” buffer was anything that didn’t meet the definition of “adequate buffer”, including native vegetation strips less than 35 feet landward. Only 32.6% of Arkdale Lake’s shoreline had an “adequate buffer”, leaving 67.4% as “inadequate.” Most of the “inadequate” buffer areas were found with small beaches, mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line. Adequate buffers on Arkdale Lake could be easily installed on most of the lake by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or—if something more controlled or aesthetically pleasing was desired—by planting native seedlings sufficient to fill in the first 35 feet.

Water Testing Results

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on Arkdale Lake. Overall, Arkdale Lake was determined to be a mildly eutrophic lake with fair to good water quality and fair water clarity.

Measuring the phosphorus in a lake system provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2006 summer average phosphorus concentration in Arkdale Lake was 29.5 micrograms/liter. This average is very close to the 30 micrograms/liter level to avoid algal blooms. This concentration suggests that Arkdale Lake is likely to have several nuisance algal blooms.

Water clarity is a critical factor for plants. If plants don’t get more than 2% of the surface illumination, they won’t survive. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Arkdale Lake in 2004-2006 was 5.17 feet. This is fair water clarity. Since 1994, water clarity in Arkdale Lake has usually averaged 4.5’ to 5.5’.

Chlorophyll-a concentration provides a measurement of the amount of algae in a lake’s water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. The 2004-2006 summer (June-September) average chlorophyll-a concentration in Arkdale Lake was 7.5 micrograms/liter, a low algal concentration for an impoundment. Chlorophyll-a averages have stayed low in Arkdale Lake since 1994, the first year for which records were found, when the average was 6.5 micrograms/liter.

Arkdale Lake water testing results showed "hard" water average of 149 mg/l $CaCO_3$). Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

A lake with a neutral or slightly alkaline pH like Arkdale Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Arkdale Lake, since its alkalinity in the surface water averages 105 milliequavalents/liter. The pH levels from the bottom of the lake to the surface hovered between 7 and 8, alkaline enough to buffer acid rain.

Some of the other water quality testing at Arkdale Lake showed no areas of concern. The average calcium level in Arkdale Lake's water during the testing period was 33.76 mg/l. The average Magnesium level was 14.58 mg/l. Both of these are low-level readings. Both sodium and potassium levels in Arkdale Lake are very low: the average sodium level 2.2 mg/l; the average potassium reading was 1.68 mg/l. For sulfate, levels of 10 mg/l or more may cause the formation of hydrogen sulfate, which smells like rotten eggs. A health advisory kicks in at 30 mg/l. Arkdale Lake water is low in sulfate. Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Very turbid waters may not only smell and mask bacteria & other pollutants, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Arkdale Lake's waters were at low levels between 2004-2006.

Some water testing results indicated a need to continue monitoring the nutrients to make sure no problems are developing. The presence of a significant amount of chloride over a period of time may indicate that there are negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. Chloride levels found in Arkdale Lake during the testing period were more than twice the natural level of 3 mg/l in this area of Wisconsin.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Arkdale Lake combination spring levels from 2004 to 2006 average 2.99 mg/l, far above the .3 mg/l predictive level. This could be a problem because the growth level of Eurasian watermilfoil, the main invasive aquatic plant species in Arkdale Lake, has been correlated with fertilization of lake sediments by nitrogen-rich runoff.

Also, in some instances, sulfate can combine with hydrogen to become the gas hydrogen sulfalte (H2S), which smells like rotten eggs and is toxic to most aquatic organisms. To avoid such formation, levels of sulfate lower than 10 mg/l are best. Arkdale Lake sulfate levels averaged 13.17 mg/l during the testing period, above the recommended 10 mg/l level, but still lower than the health advisory level of 30 mg/l.

Phosphorus

Like most lakes in Wisconsin, Arkdale Lake is a phosphorus-limited lake: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other water quality aspects.

The total phosphorus (TP) concentration in a lake is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a man-made lake like Arkdale Lake, a total phosphorus concentration below 30 micrograms/liter tends to result in few nuisance algal blooms. Arkdale Lake's growing season (June-September) surface average total phosphorus level of 29.5 micrograms/liter is very close to that limit.

Land use plays a major role in phosphorus loading. The land uses around Arkdale Lake that contribute the most phosphorus are the ground watershed and the upstream Big Roche a Cri surface watershed. Some phosphorus deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration along waterways; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Such practices need to be implemented in all of the Big Roche a Cri Creek Watershed in order for a significant impact on phosphorus reduction to occur.

Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% would improve Arkdale Lake water quality by reducing the total phosphorus levels 2 to 10 micrograms of phosphorus/liter; a 25% reduction would save 6 to 19 micrograms/liter. Reductions of 25% could put the lake low enough in total phosphorus levels that algal blooms would be greatly reduced. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Arkdale Lake's health for future generations.

Aquatic Plant Community

The aquatic plant community of Arkdale Lake is characterized by below average quality and good species diversity. The plant community suggests that Arkdale Lake is in the group of lakes in Wisconsin and the North Central Hardwoods Region that are most tolerant of disturbance.

The Arkdale Lake aquatic plant community has colonized 86% of the littoral zone and about half the lake overall. The 0-1.5' and 1.5'-5' depth zones support the most abundant aquatic plant growth. The dominant species in Arkdale Lake was *Vallisneria americana* (water celery). Sub-dominant was *Wolffia* spp (common waterweed).

Myriophyllum spicatum (Eurasian watermilfoil), an aggressive invasive species, was introduced to Arkdale Lake in the early 2000s. So far, no aquatic invasive treatment/control plan has been developed for Arkdale Lake. The Arkdale Lake Association is currently drafting a lake management plan that will include an aquatic plant management plan and invasive species control plan.

Other Invasives

Besides the aquatic invasive plant Eurasian watermilfoil, Arkdale Lake is plagued with rusty crayfish, a large aggressive non-native crayfish that tends to out-compete the native crayfish, as well as disrupt the fish food chain and denude lake bottoms of needed aquatic plants. The lake management plan will also need to address this issue.

Critical Habitat Areas

Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes. Two areas on Arkdale Lake were determined by a team of lake professionals to be appropriate for critical habitat designation.

AR1 extends along the entire northeast end of the lake and the eastern end of the north shore, with an average water depth of less than 2' in the most eastern end and of less than 3' along the north shore. 25% of the shore is wooded; 55% is native herbaceous cover and 20% is shrubs. Some woody cover is present for habitat. Human disturbance impact on this area is currently limited, perhaps partially due to the very shallow waters. Aquatic vegetation found at AR1 included six emergent plants, two free-floating plants and six submergent species. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. The free-floating species are used for food and cover by various fish and wildlife. Filamentous algae were also abundant here.

AR2 extends along the 425' of the south shoreline with an average water depth of less than 5'. 40% of the shore is wooded; 23% is native herbaceous cover and 35% is shrubs. Some woody cover is present for habitat. This area is a small section of currently undeveloped shore, with development present on both sides of it. Human disturbance impact on this particular area is currently limited. Only one species of emergent aquatic vegetation found at AR2. Two types of rooted, floating-leaf aquatic species were present at this site, as well as three species of free-floating aquatic plants. Six submergent species were found, but no exotic invasive plant species. Filamentous algae were also abundant here.

<u>Fish/Wildlife/Endangered Resources</u>

WDNR fish stocking records for Arkdale Lake go back to 1935, when northern pike, bullheads and bass were put into the lake. An evaluation in 1971 determined that the lake was best suited for northern pike, largemouth bass and panfish. The most recent WDNR survey (1995) of Arkdale Lake indicated that northern pike and white sucker were abundant. Yellow perch, black crappie and bluegills were common, but largemouth bass, walleye, spotted sucker and pumpkinseed were scarce. Recent reports from lake users express the belief the fishing has declined since the infestation by rusty crayfish. Aquatic plant growth at the eastern end of the lake has declined since that infestation as well. A plan for diminishing the impact of rusty crayfish needs to be developed by the Arkdale Lake Association.

Seen during the field survey were various types of waterfowl and songbirds. Frogs and salamanders are known, using the lakeshore for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well.

The Arkdale Lake watersheds are home to many endangered resources. Endangered natural communities found in these watersheds include floodplain forest, lake (shallow, hard, seepage), northern sedge meadow, northern wet forest, pine barrens and shrub-carr. Endangered, threatened or special concern plant species found in these watersheds are Crossleaf Milkwort, Engelmann Spikerush, Grassleaf Rush, One-Flowered Broomrape, Slim-stem Small-reedgrass, Whip Nutrush and Yellow Screwstem. Karner Blue Butterfly, Persius Dusky Wing Butterfly and Sand Snaketail Dragonfly.

Conclusion

Arkdale Lake is currently a small impoundment impacted substantially by its large upstream surface greater watershed and its very large ground watershed. The Arkdale Lake Association is currently working on a lake management plan that will begin to address management issues in a logical, cohesive manner. Attempts in the past, while well-intentioned, were not coordinated or focused. It is hoped that the recommendations on the following pages and the information in this report will help in these aims.

RECOMMENDATIONS

Lake Management Plan

Arkdale Lake Advisory Group has written a lake management plan and submitted it to the WDNR for approval. This plan includes the following aspects concerning the management of the lake (as well as others): aquatic plant management; control/management of invasive species, including rusty crayfish; wildlife and fishery management; watershed management; shoreland protection; critical habitat protection; water quality protection; inventory & management of the larger watershed.

Watershed Recommendations

With such a large ground watershed and large point nutrient source of the very large upper watershed, results of the modeling suggest input of nutrients, especially phosphorus, are factors that need to be explored for Arkdale Lake.

Therefore, it is recommended that both the surface and ground watersheds be inventoried, documenting any of the following: runoff from any livestock operations that may be entering the surface water; soil erosion sites; agricultural producers not complying with nutrient management plans and/or irrigation water management plans. If such sites are documented, steps for dealing with these issues can be incorporated into the lake management plan.

The Arkdale Lake Association should consider approaching the WDNR or conservancy organizations to explore putting the east end of the lake, with its meandering stream and wetlands, into a conservancy or limited development area to assure that those areas won't be changed in a way that would degrade water quality of the lake.

Shoreland Recommendations

Based on the 2005 aquatic plant survey and the 2004 shoreland survey, the following recommendations are made concerning aquatic plants and aquatic invasive species:

> All lake residents should practice best management on their lake properties, including keeping septic systems cleaned and in proper condition, eliminating the use of lawn fertilizers, cleaning up pet wastes and not composting near the water.

Aquatic Plant/Aquatic Invasive Species

1) Residents should continue involvement in the Citizen Lake Water Monitoring, Invasive Species Monitoring and Clean Boats, Clean Waters Programs. This will allow not only noting changes in the Eurasian Watermilfoil pattern, but also discover any other invasions. Noting the presence and density of these species early is the best way to take preventive action to keep them from becoming a bigger problem.

2) Lake residents should protect and restore natural shoreline around Arkdale Lake. Studies have shown that there is lower frequency and density of the most sensitive plant species in disturbed shoreline areas. Disturbed shoreline sites support an aquatic plant community that is generally less able to resist invasions of exotic species and show impacts from nutrient enrichment.

3) All lake users should protect the aquatic plant community in Arkdale Lake by such practices as disturbing aquatic plant areas as little as possible, removing invasives species, reducing sedimentation and controlling erosion.

4) The Arkdale Lake Association should maintain exotic species signs at the boat landings and contact DNR if the signs are missing or damaged.

5) The Arkdale Lake Association should continue monitoring and control of Eurasian Watermilfoil using the most effective methods, with modification if necessary. Early-season treatments with a specific chemical might be considered to know back the plant, followed by a regular harvesting schedule and pattern. Residents should be encouraged to hand-pull scattered EWM plants.

6) The lake management plan needs to include a multi-pronged approach for the management and/or control of rusty crayfish.

Critical Habitat Recommendations

There are also several recommendations appropriate for the critical habitat areas:

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove any fallen trees along the shoreline.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.

(5) Maintain any snag/cavity trees for nesting.
(6) Install nest boxes.
(7) Maintain or increase wildlife corridor.
(8) Maintain no-wake lake designation.
(9) Protect emergent vegetation.
(10) Seasonal control of Eurasian Watermilfoil with methods selective for control of exotics.
(11) Develop & implement control plan for invasive Rusty Crayfish.
(12) Minimize aquatic plant and shore plant removal to maximum 30' wide viewing/access corridor and navigation purposes. Leave as much vegetation as possible to protect water quality and habitat.
(13) Use best management practices.
(14) No use of lawn products.
(15) No bank grading or grading of adjacent land.
(16) No pier placement, boat landings, development or other shoreline disturbance in the shore area of the wetland corridor.
(17) No pier construction or other activity except by permit using a case-by-case evaluation and only using light-penetrating materials.
(18) No installation of pea gravel or sand blankets.
(19) No bank restoration unless the erosion index scores moderate or high.
(20) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(21) Placement of swimming rafts or other recreational floating devices only by permit.
(22) Maintain aquatic vegetation buffer in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post exotic species information at public boat landing.

LAKE CLASSIFICATION REPORT FOR ARKDALE LAKE, ADAMS COUNTY

INTRODUCTION

In 2003, The Adams County Land & Water Conservation Department (Adams County LWCD) determined that a significant amount of natural resource data needed to be collected on the lakes with public access in order to provide it and the public with information necessary to manage the lakes in a manner that would preserve or improve water quality and keep it appropriate for public use. In some instances, there was significant historical data about a particular lake; in that instance, the study activities concentrated on combining and updating information. In other instances, there was no information on a lake, so study activities concentrating on gathering data about that lake. Further, it was discovered that information was scattered among various citizens, so often what information was actually available regarding a particular lake was unknown. To assist in updating some information and gathering baseline information, plus centralize the data collected, so the public may access it. The Adams County LWCD received a series of grants from the Wisconsin Department of Natural Resources (WDNR) from the Lake Classification Grant Program.

Objectives of the study were:

- collect physical data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- collect chemical and biological data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- develop a library of lake information that is centrally located and accessible to the public and to City, County, State and Federal agencies.
- make specific recommendations for actions and strategies for the protection, preservation and management of the lakes and their watersheds.
- create a baseline for future lake water quality monitoring.
- Provide technical information for the development of comprehensive lake management plans for each lake
- provide a basis for the water quality component of the Adams County Land and Water Resource Management Plan. Components of the plan will be incorporated into Adams County's "Smart Growth Plan".
- develop and implement educational programs and materials to inform and education lake area property owners and lake users in Adams County.

METHODS OF DATA COLLECTION

To collect the physical data, the following methods were used:

- delineation & mapping of ground & surface watersheds using topographic maps, ground truthing and computer modeling;
- identification of flow patterns for both the surface & ground watersheds using known flow maps and topographic maps;
- inventory & mapping of current land use with orthographic photos and collected county information;
- inventory & mapping of shoreline erosion and buffers using county parcel maps and visual observation;
- inventory & mapping for historical and cultural sites using information from the local historical society and the Wisconsin Historical Society;
- identification & mapping of critical habitat areas with WDNR and Adams County LWCD staff;
- identification & mapping of endangered or threatened natural resources (including natural communities, plant & animal species) using information from the Natural Heritage Inventory of Wisconsin;
- identification & mapping of wetland areas using WDNR and Natural Resource Conservation Service wetland maps;
- preparation of soil maps for each of the lake watersheds using soil survey data from the Natural Resource Conservation Service.

To collect water quality information, different methods were used:

- for three years, lakes were sampled during late winter, at spring and fall turnover, and several times during the summer for various parameters of water quality, including dissolved oxygen, relevant to fish survival and total phosphorus, related to aquatic plant and algae growth;
- random samples from wells in each lake watershed were taken in two years and tested for several factors;
- aquatic plant surveys were done on all 20 lakes and reports prepared, including identification of exotics, identifying existing aquatic plant community, evaluation of community measures, mapping of plant distribution, and recommendations;
- all lakes were evaluated for critical habitat areas, with reports and recommendations being made to the respective lakes and the WDNR;
- lake water quality modeling was done using data collected, as well as historical data where it was available.

WATER QUALITY COMPUTER MODELING

Wisconsin developed a computer modeling program called WiLMS (Wisconsin Lake Modeling Suite) to assist in determining the amount of phosphorus being loaded annually into a lake, as well as the probable source of that phosphorus. This suite has many models, including Lake Total Phosphorus Prediction, Lake Eutrophic Analysis Procedure, Expanded Trophic Response, Summary Trophic Response, Internal Load Estimator, Prediction & Uncertainty Analysis, and Water & Nutrient Outflow. The models that various types of data inputs: known water chemistry; surface area of lake; mean depth of lake; volume of lake; land use types & acreage. This information is then used in the various models to determine the hydrologic budget, estimated residence time, flushing rate, and other parameters.

Using the data collected over the course of the studies, various models were run under the WiLMS Suite. These water quality models are computer-based mathematical models that simulate lake water quality and watershed runoff conditions. They are meant to be a tool to assist in predicting changes in water quality when watershed management activities are simulated. For example, a model might estimate how much water quality improvement would occur if watershed sources of phosphorus inputs were reduced. However, it should be understood that these models predict only a relative response, not an exact response. Modeling results will be incorporated into topic discussions as appropriate.

DISSEMINATION OF PROJECT DELIVERABLES

The results of this study will be distributed various agencies, organizations and the public as previously described. Based on the classification information, the Adams County Land and Water Conservation Department will identify assistance requests and determine the appropriate future activities, based on the classification determinations. To provide the requested assistance, Adams County Land and Water Conservation Department will incorporate the lake management plans goals, priorities and action items into its Annual Plan of Operations. Goals, priorities and action items may include educational programs, formation of lake districts, further development of lake management plans and implementation of lake management plans.

ADAMS COUNTY INFORMATION

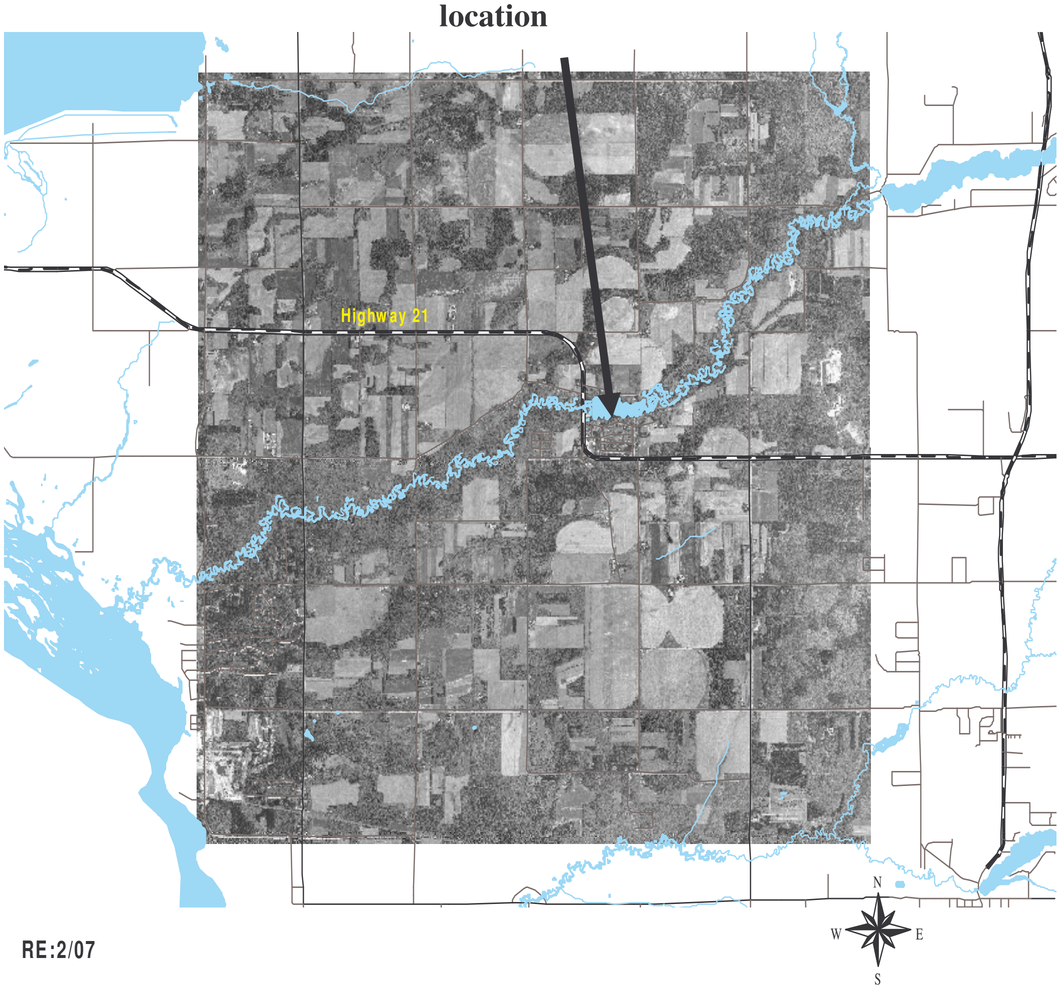
Adams County lies in south central Wisconsin, shaped roughly like the outline of Illinois. Adams County is a small rural county with a full-time population of about 20,000. Between 1980 and 2000, Adams County's population grew by more than 20%, with most of the population increase being located upon the lakes and streams. The population increase has resulted in a greater need for facilitation, technical assistance and education, including information on the lakes and streams.

Figure 1: Adams County Location in Wisconsin

ARKDALE LAKE BACKGROUND INFORMATION

Arkdale Lake is a 47-acre impoundment (man-made lake) located in the Town of Strongs Prairie, Adams County, in the Central Sand Plains Area of Wisconsin. As an impoundment of Big Roche a Cri Creek, it has both an inlet and outlet. Through Arkdale Lake moves input of a very large watershed that extends into the next county east.

Figure 2: ARKDALE LAKE location

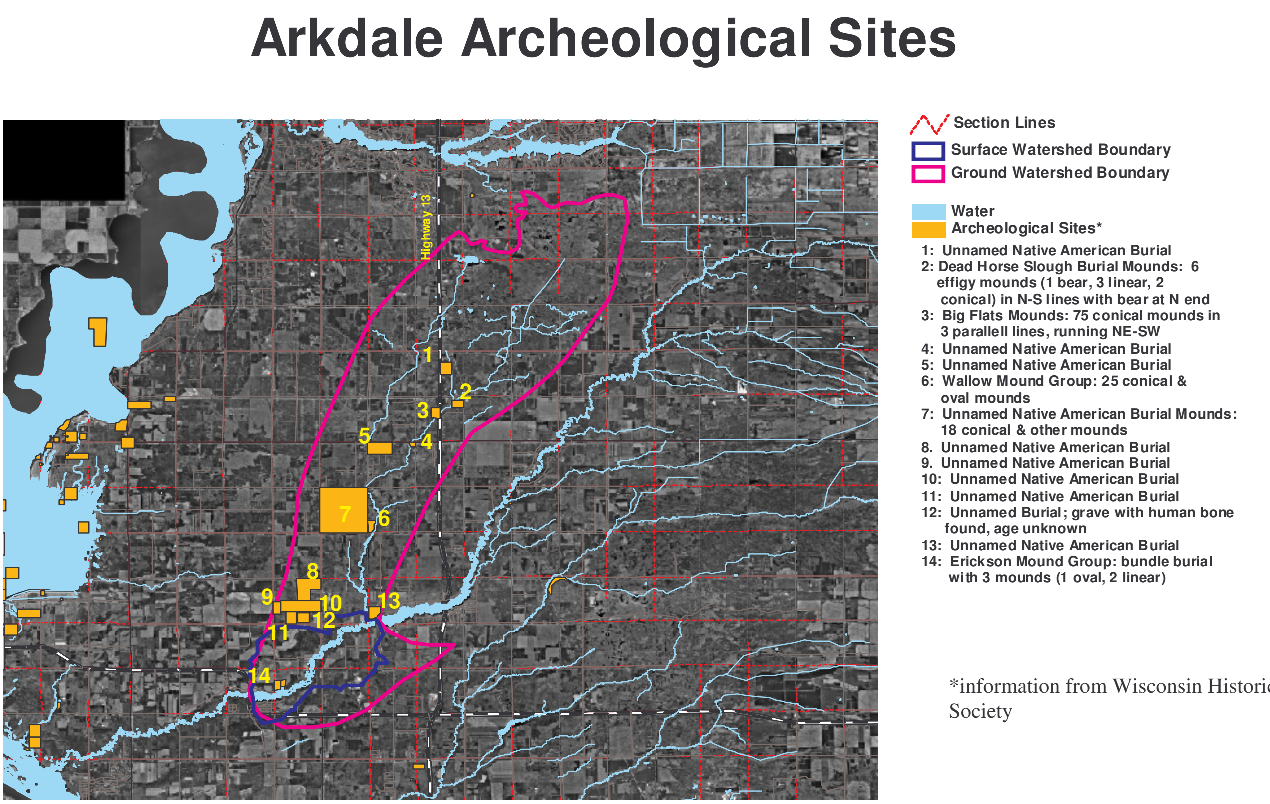


Arkdale Lake is part of the Big Roche a Cri Creek, a large watershed of 177 square miles from which water flows eventually into the Wisconsin River. The Central Sand Plains, which contain Arkdale Lake, are found in the Driftless Area of Wisconsin. The area is characterized by varying elevations, with numerous, usually flat-topped ridges & hills sometimes called "mounds." Deposits made by streams from the melting ice sheet cover large areas and usually consist of sand, clay and gravel.

<u>Archeological Sites</u>

There are many Native American archeological sites in Adams County, with some located in the Arkdale Lake watersheds. Under the federal act on Native American burials, these sites cannot be further disturbed without permission of the federal government and input from the local tribes.

Figure 3: Arkdale Lake Archeological Sites



*information from Wisconsin Historical Society

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Bedrock and Historical Vegetation

Bedrock around Arkdale Lake is mostly sandstone, both weak and resistant, formed in the Cambrian Period of Geology (542 to 488 millions years ago). Bedrock may be 200 or more feet below the sand/clay/gravel deposits left by melting ice cover.

Original upland vegetation of the area included extensive wetlands of many types (including open bogs, shrub swamps & sedge meadows), as well as prairies, oak forests, savannahs and barrens. Mesic white pine & hemlock forests were found in the northwest portion of the region. Most of the historic wetlands were drained in the 1900s and used for cropping. The current forested areas are mostly oak-dominated, followed by aspen and pines. There are also small portions of maple-basswood forest and lowland hardwoods.

Soils in the Arkdale Lake Watersheds

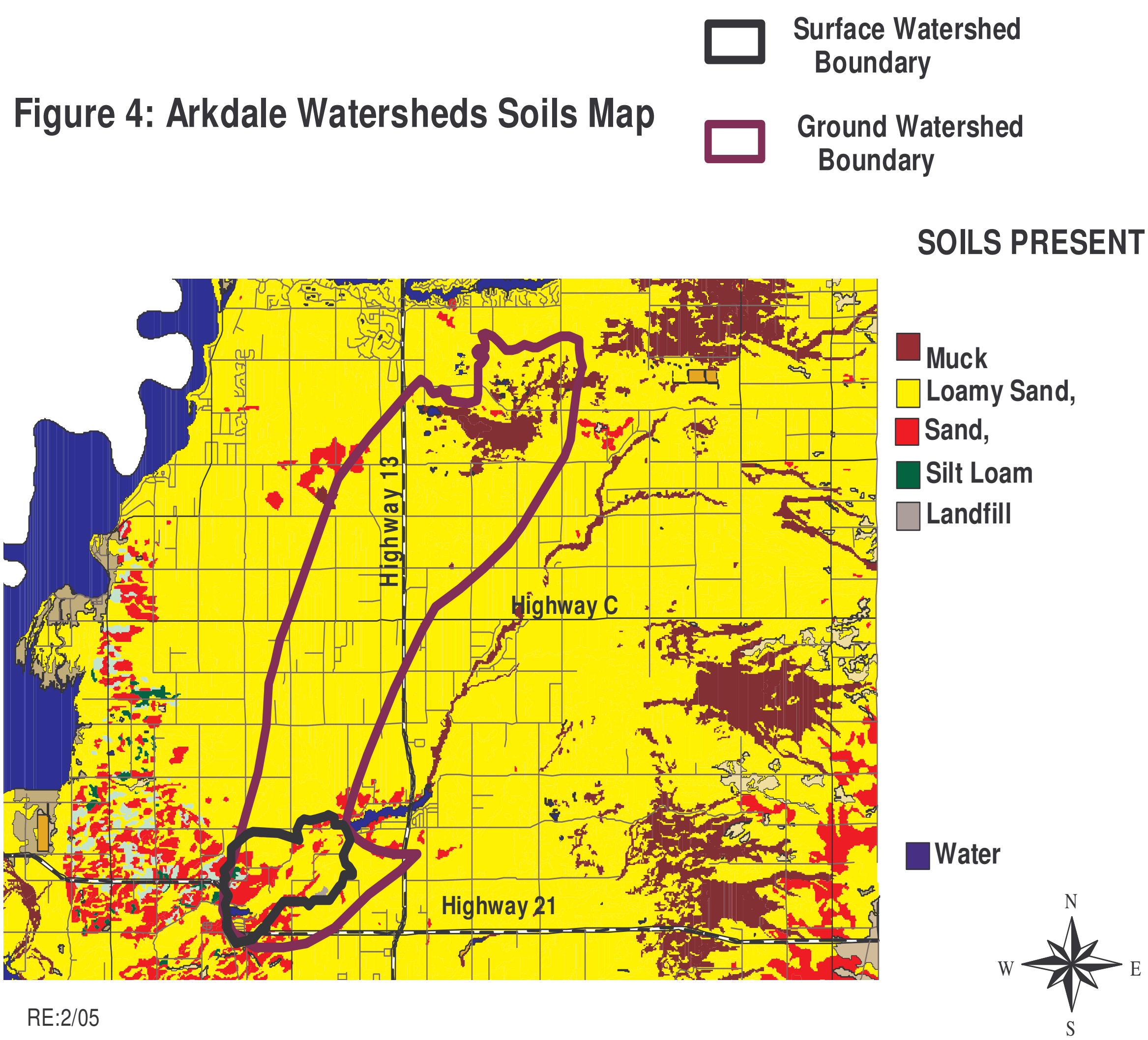
Except for some pockets of muck and silt loam, the soils in the surface and ground watersheds for Arkdale Lake are loamy sand and sand, with slopes from very flat up to 45% (see Figure 4). Sandy soils occupy 62.8% of the ground watershed and 26.9% of the surface watershed. 29% of the ground watershed is covered with loamy sand, which also covers 66.3% of the surface watershed.

Sandy soil tends to be excessively drained, no matter what the slope. Water, air and nutrients move through sandy soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Although water erosion can be a problem, wind erosion may be more of a hazard with sandy soils, especially since these soils dry out so quickly. There are also draught hazards with sandy soils. Getting vegetation started in sandy soils is often difficult due to the low available water capacity, as well as low natural fertility and organic material. Onsite waste disposal in sandy soils is also a problem because of slope and seepage; mound systems are usually required.

Loamy sands tend to be well-drained, with water, air and nutrients moving through them at a rapid rate. Runoff, when it occurs, tends to be slow. Loamy sands have little water-holding capacity and low natural fertility, although they usually have more organic matter present than do sandy soils. Both wind and water erosion are potential hazards with loamy sands, as is draught. The same difficulties with waste disposal and vegetation establishment are present with loamy sands as with sandy soils.

The soil and soil slopes around lakes and streams are very important to water quality. They affect amount of infiltration of surface precipitation into the ground and the amount of contaminants that may reach the groundwater, as well as the amount of surface stormwater runoff. In addition, these two factors affect the amount and content of pollutants and particles (including soil) that may wash into a water body, affecting its water quality, its aquatic plant community and its fishery. Further, soil types and soil slopes help determine the appropriate private sewage system and other engineering practices for a particular site, since they affect absorption, filtration and infiltration of contamination from engineering practices.

Figure 4: Arkdale Watersheds Soils Map



CURRENT LAND USE

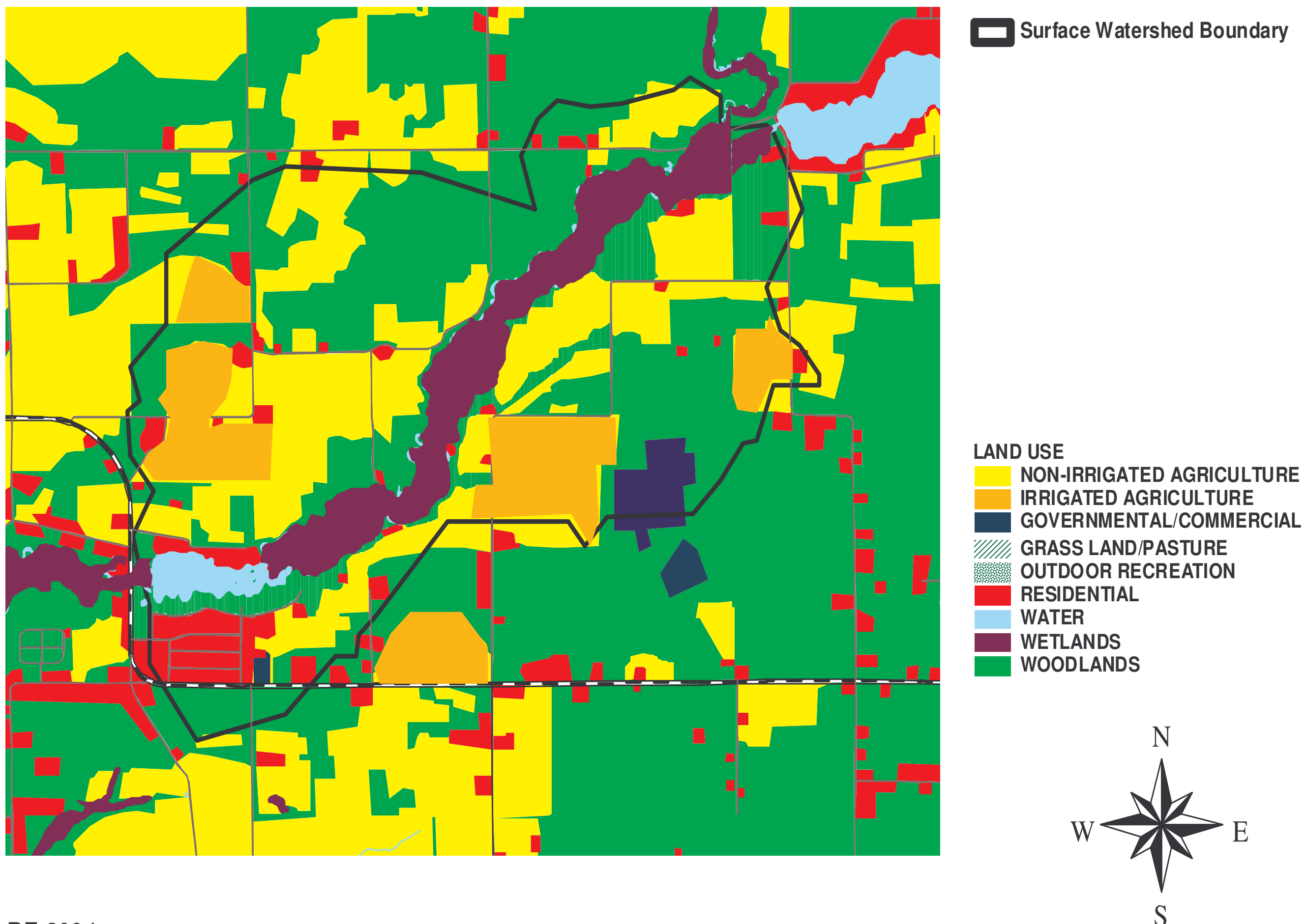
Although the surface watershed for Arkdale Lake is quite small, the ground watershed is very large. Arkdale Lake also receives significant input of materials from the large upper watershed. In the surface watershed, the main two land use types are Woodlands and Non-irrigated Agriculture. In the ground watershed, woodlands dominate. (See Figures 5, 6a, 6b & 7).

Figure 5: Arkdale Lake Watersheds Land Use in Acres and Percent of Total

	Acres Surface		Acres Ground		Acres Total	
Arkdale Lake						
Agriculture--Non Irrigated	841.87	30.77%	931.14	4.53%	1773.01	7.61%
Agriculture--Irrigated	288.1	10.53%	370	1.80%	658.1	2.83%
Government	88.65	3.24%	160.33	0.78%	248.98	1.07%
Grassland/Pasture	0	0.00%	631.04	3.07%	631.04	2.71%
Residential--Med Density	132.2	4.81%	0	0.00%	132.2	0.57%
Residential--Rural Density	200	7.32%	2861.26	13.92%	3061.26	13.14%
Water	288.1	10.53%	1050.36	5.11%	1338.46	5.75%
Woodland	897.13	32.80%	14,550.88	70.79%	15448.01	66.32%
total	2736	100.00%	20,555	100.00%	23291	100.00%

Studies have shown that land use around a lake has a great impact on the water quality of that lake, especially in the amount and content of surface runoff. (James, T., 1992, I-10; Kibler, D.F., ed. 1982. 271) For example, while natural woodland may (on the average) absorb 3.5" out of a 4" rainfall, leaving only .5" as runoff, a residential area with quarter-acre lots may absorb only 2.3" of the 4", leaving 1.7" to run off the land into the lake—the same amount as may be expected to run off from a corn or soybean field. 1.7" of runoff translates into 46,200 gallons per acre ending up in the lake! Percentage of impervious surface, the soil type, vegetation present and slope of the site can all affect runoff volume. (Frankenberger, J, ID-230).

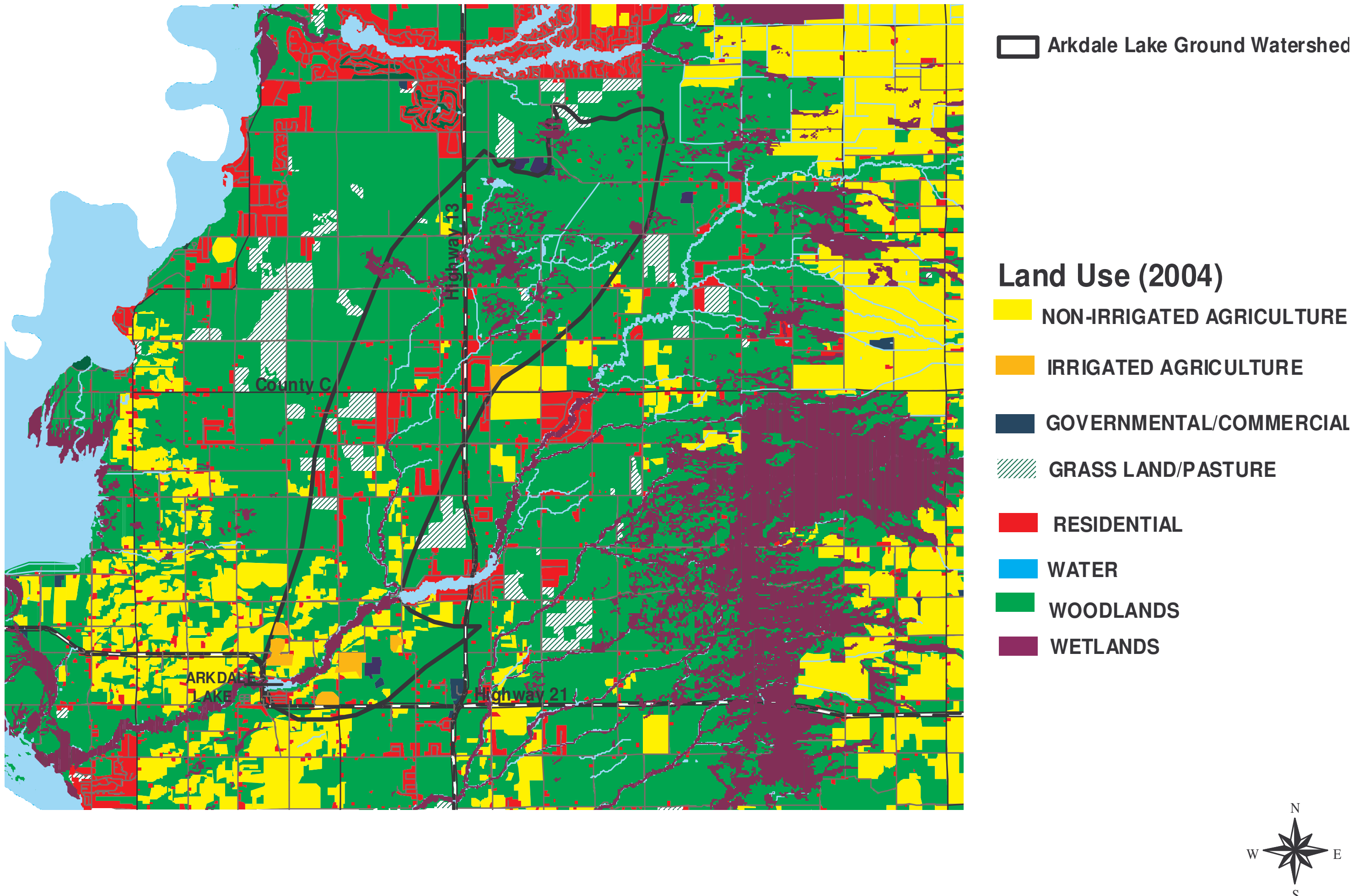
Land Use--Arkdale Lake Surface Watershed



RE:2004

Figure 6a: Land Use in Arkdale Lake Surface Watershed

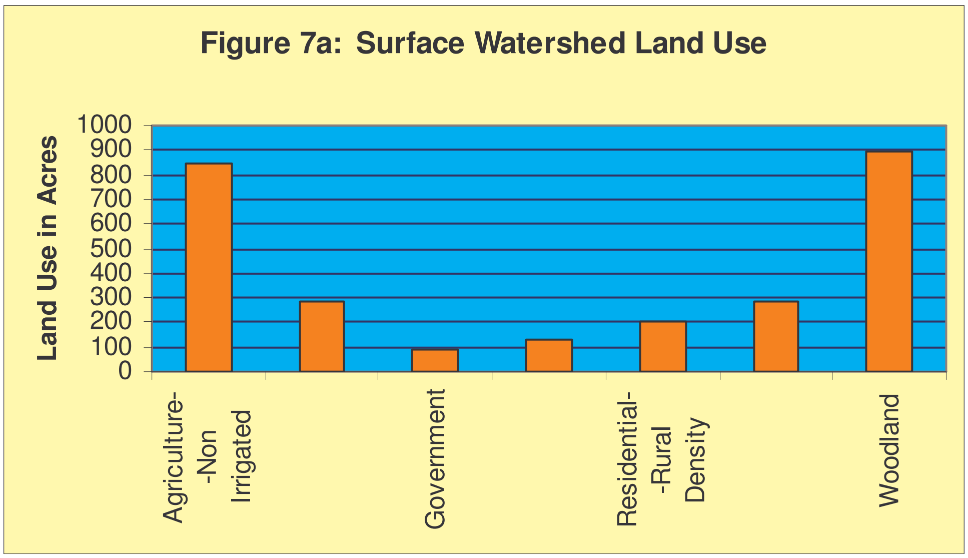
ARKDALE LAKE GROUND WATERSHED--LAND USE

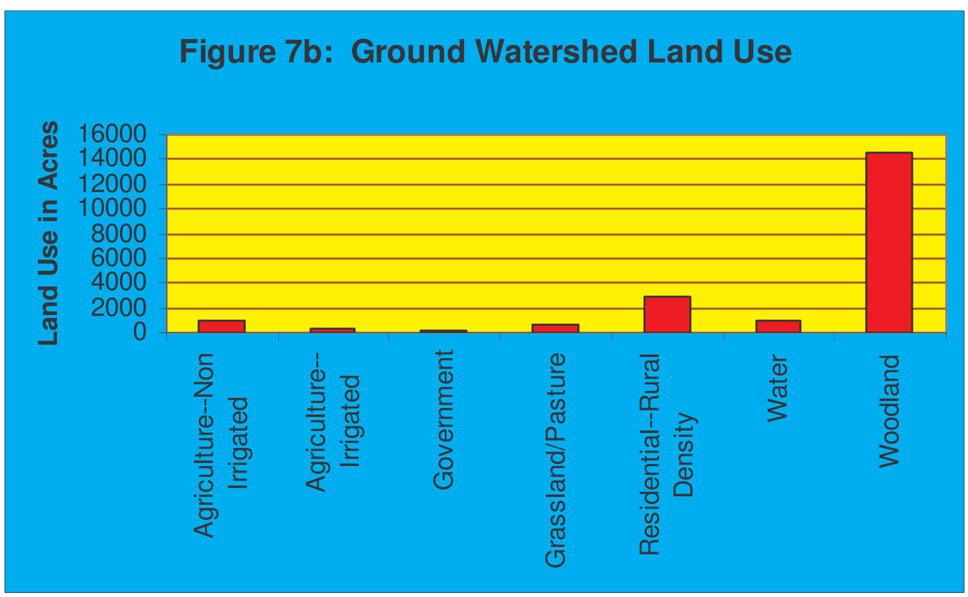


RE:2/05

Figure 6b: Land use in Arkdale Lake Ground Watershed

When water runs over a surface, it picks up whatever loose pollutants—sediment, chemicals, metals, exhaust gas, etc—are present on that surface and takes those items with it into the lake. Increased development around a lake tends to increase the amount of pollutants being carried into the lake, thus negatively affecting water quality. Residential development areas with lots of one-quarter acre or less may deliver as much as 2.5 pounds of phosphorus per year to the lake for each acre of development.





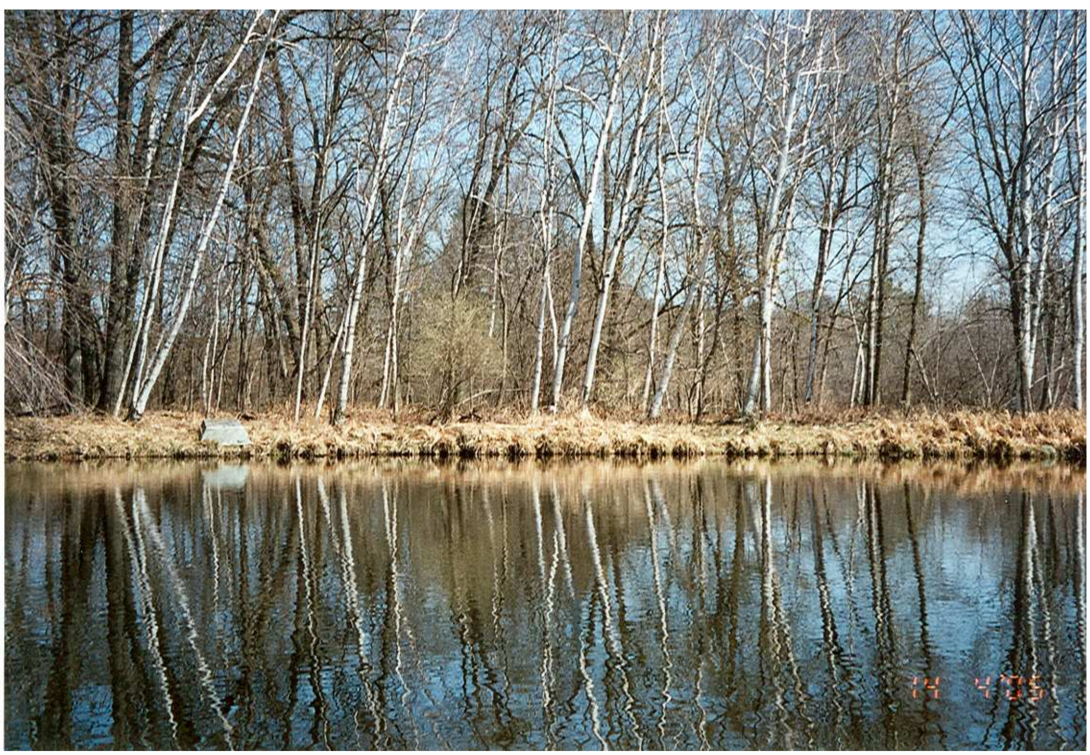
There are two specific kinds of land use—wetlands and shorelands--that are so important to water quality that they will be separately discussed.

WETLANDS

A number of wetlands are located in the Arkdale Lake surface and ground watersheds, especially before and after the lake (Figures 6a & 6b). In the past, wetlands were seen as “wasted land” that only encouraged disease-transmitting insects. Many wetlands were drained and filled in for cropping, pasturing, or even residential development. In the last few decades, however, the importance of wetlands has become evident, even as wetlands continue to decline in acreage.

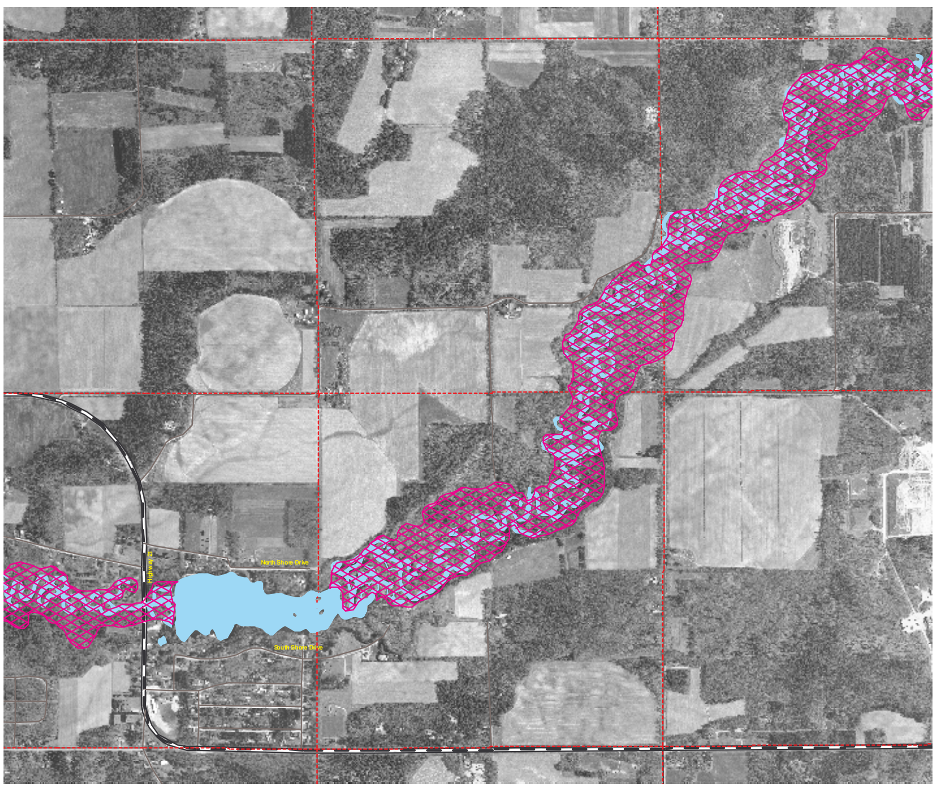
Wetlands play an important role in maintaining water quality by trapping many pollutants in runoff and flood waters, thus often helping keep clean the water they connect to. They serve as buffers to catch and control what would otherwise be uncontrolled water and pollutants. Wetlands also play an essential role in the aquatic food chain (thus affecting fishery and water recreation), as well as serving as spaces for wildlife habitat, wildlife reproduction and nesting, and wildlife food.

Figure 8: Arkdale Lake wooded shore wetland



The photo above (Figure 8) shows one of the wetlands along the shore of Arkdale Lake. Looking at the map of wetlands directly around Arkdale Lake (see Figure 9) makes it evident how important wetlands are to Arkdale Lake…much of the lake has wetlands at or near the shore that serve as filters and trappers that help keep the lake as clean as it is. It is essential to preserve these wetlands for the health of Arkdale Lake.

Figure 9: Arkdale Lake Wetlands



RE:5/05
revised 6/06

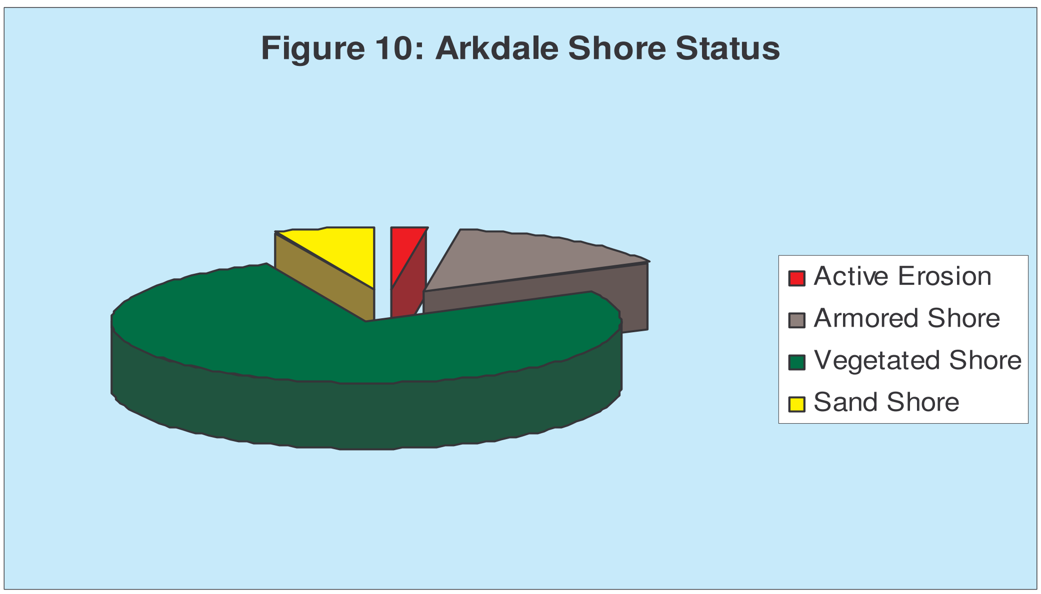
Wetlands
Section Lines

*information from Wisconsin Department of Natural Resources & Natural Resource Conservation Service

N W E S

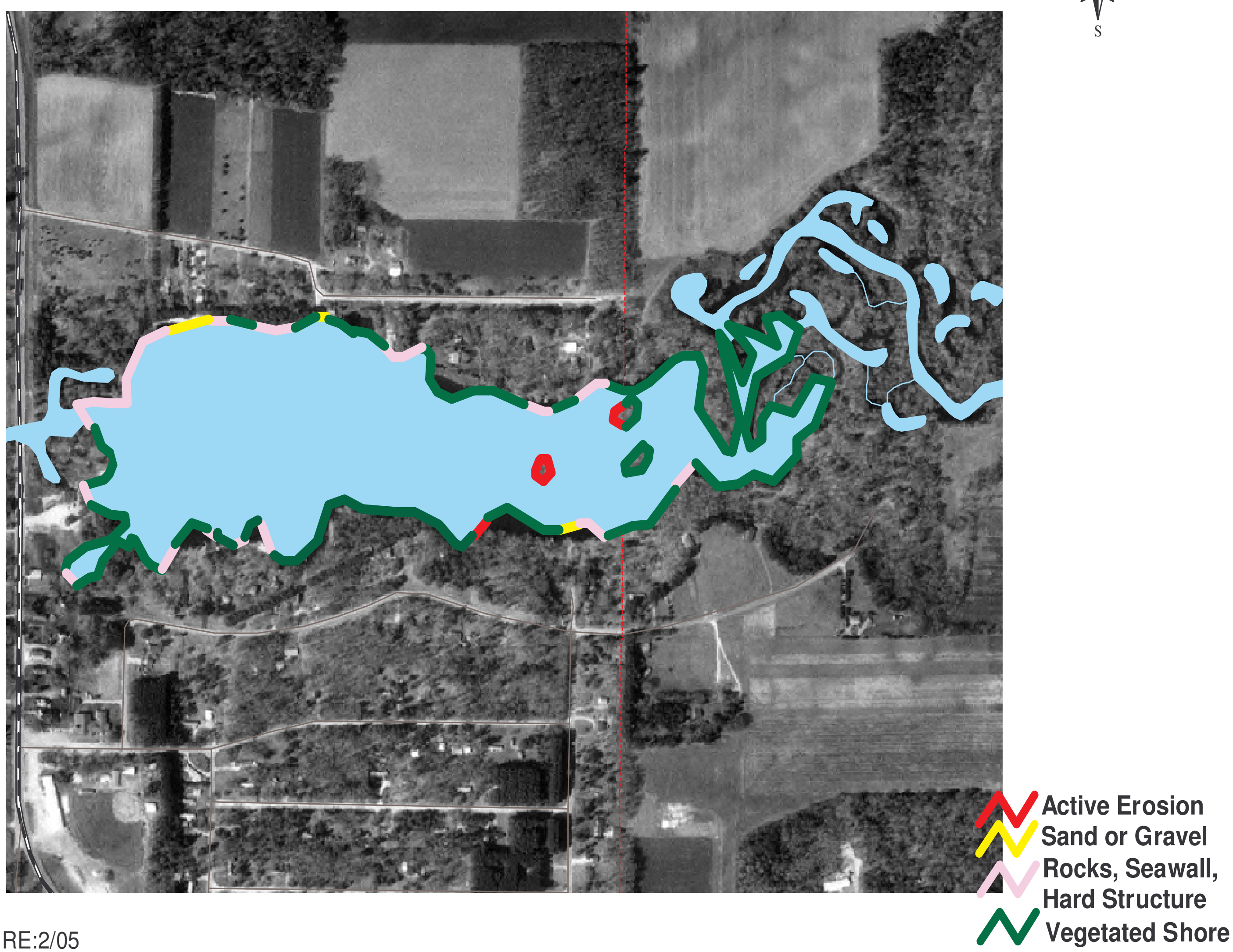
SHORELANDS

Arkdale Lake has a total shoreline of 4.1 miles (21,648 feet). This includes several channels at the northeast end of the lake that wind in and out of a bog and a sedge meadow that have not been developed. The rest of the lakeshore is in residential use. While of the areas on the south shore are steeply sloped, the land is flatter on the north, west and east sides.



Over half of Arkdale Lake's shoreline is vegetated. The rest of the shore is active erosion, armored shore, sandy beach shores or mixtures thereof.

Shoreline of Arkdale Lake



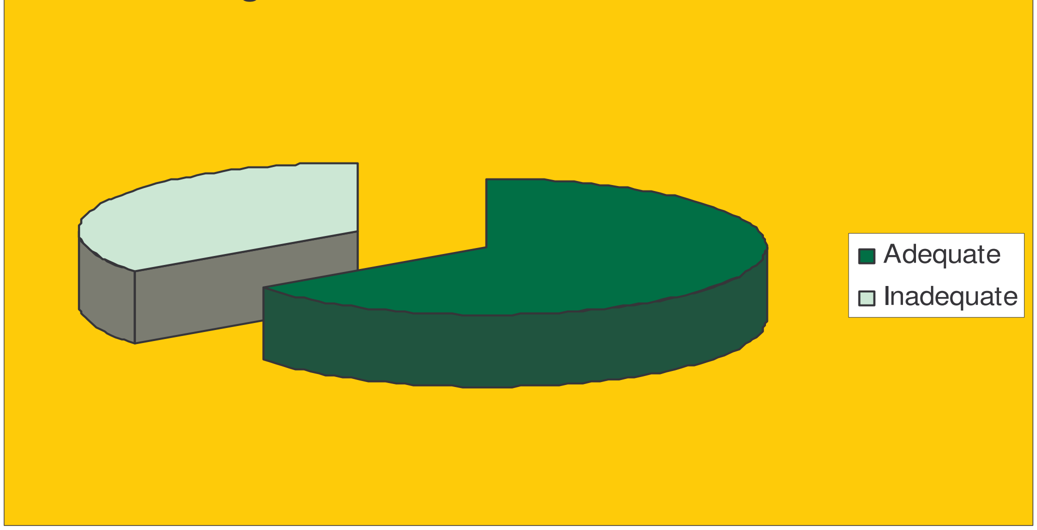
RE:2/05

Figure 11: Arkdale Lake Shoreline Map

The Adams County Shoreline Ordinance defines 1000' landward from the ordinary high water mark as "shoreland". Under the ordinance, the first 35 feet landward from the water is a "buffer." Shoreland buffers are an important part of lake protection and restoration. These buffers are simply a wide border of native plants, grasses, shrubs and trees that filter and trap soil & similar sediments, fertilizer, grass clippings, stormwater runoff and other potential pollutants, keeping them out of the lake. A 1990 study of Wisconsin shorelines revealed that a buffer of native vegetation traps 5 to 18 times more volume of potential pollutants than does a developed, traditional lawn or hard-armored shore.

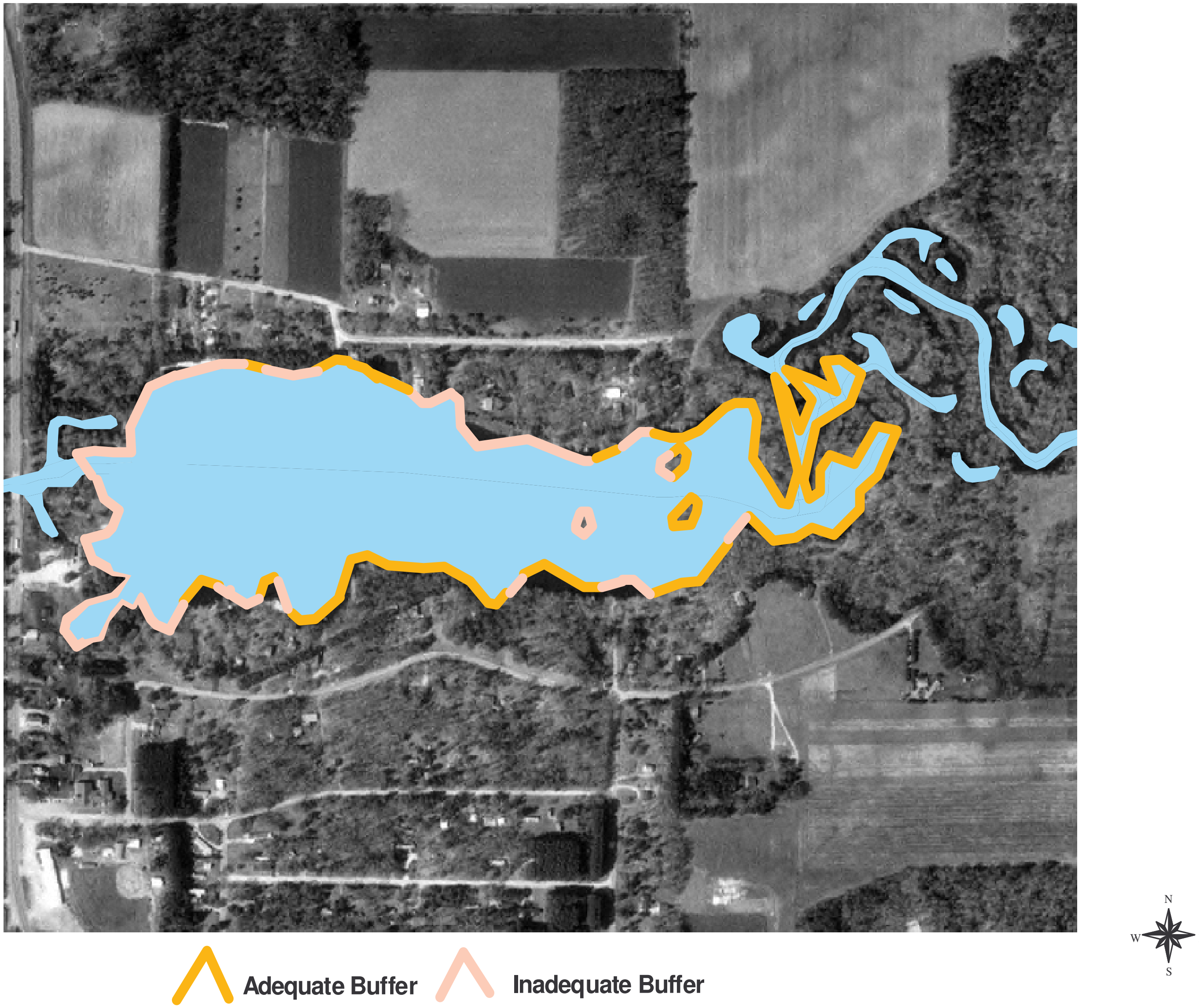
The 2004 inventory included classifying areas of the Arkdale Lake shorelines as having "adequate" or "inadequate" buffers (see Figure 13). An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, 65.67% (about 8126 feet) of Arkdale Lake's shoreline had an "adequate buffer", leaving 35.33% (4440 feet) as "inadequate." Most of the "inadequate" buffer areas were found with traditional mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.

Figure 12: Arkdale Lake Buffer Status



Vegetated shoreland buffers help stabilize shoreline banks, thus reducing bank erosion. The plant roots give structure to the bank and also increase water infiltration and decrease runoff. A vegetated shore is especially important when shores are steep and soft, as are many of the Arkdale Lake shores. Figure 13 maps the adequate and inadequate buffers on Arkdale Lake.

Buffers on Arkdale Lake



RE:2/05

Figure 13: Arkdale Lake Buffer Map

Lakeside buffers also serve as important habitat. Lake edges usually contain aquatic and wetland plants, grading into drier groundcover, then shrubs and trees as one moves inland towards drier land. Buffers provide habitat for many species of water-dependent wildlife, including furbearers, reptiles, birds and insects. Many wildlife species, including birds, small mammals, fish & turtles breed, nest, forage and/or perch in shore buffer areas. Further, 80% of the endangered and threatened species listed spend part of their life in this near-lake buffer area. (Wagner et al, 2006)

When the natural shoreline is replaced by traditional mowed turf-grass lawns, rock, wooden walls or similar installments, bird and animal life, land-based insects, and aquatic insects that hatch or winter on natural shore are negatively impacted. For example, on many Adams County lakes, the non-native aquatic plant, Eurasian Watermilfoil has invaded. There is a weevil native to Wisconsin that weakens Eurasian Watermilfoil by burrowing into and developing within its stems, but that weevil depends on a native-plant shore to overwinter. If the shore is instead covered by rock, seawall or traditional lawn, these weevils will be unavailable for the lake to use as Eurasian Watermilfoil control.

Figure 14: Example of Inadequate Vegetative Buffer

The filtering process and bank stabilization that buffers provide help improve a lake's water quality, including water clarity. Studies in Minnesota, Maine and Michigan have shown that waterfront property value increases for every foot the water clarity of a lake increases. (Krysel et al, 2003).

Figure 15: Example of Adequate Buffer

Natural shoreland buffers serve important cultural functions. They enhance the lake's aesethics. Studies have shown that aeshetics rank high as one of the reasons people visit or live on lakes. Shore buffers can provide visual & audio privacy screens for homeowners from other neighbors and/or lake users.

Adequate buffers on Arkdale Lake could be easily installed on most of the inadequate areas by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or—if something more controlled or aesthetically pleasing was desired—by planting native seedlings sufficient to fill in the first 35 feet or using biologs to protect the shore that are vegetated.

WATER QUALITY

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on 20 lakes in Adams County with public access. Arkdale Lake was one of these lakes. Part of the information was gained from periodic water sampling done by Adams County LWCD. Historic information about water testing on Arkdale Lake was also obtained from the WDNR in a series of 1994 tests.

Phosphorus

Most lakes in Wisconsin, including Arkdale Lake, are phosphorus-limited lakes: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects. One pound of phosphorus can produce as much as 500 pounds of algae.

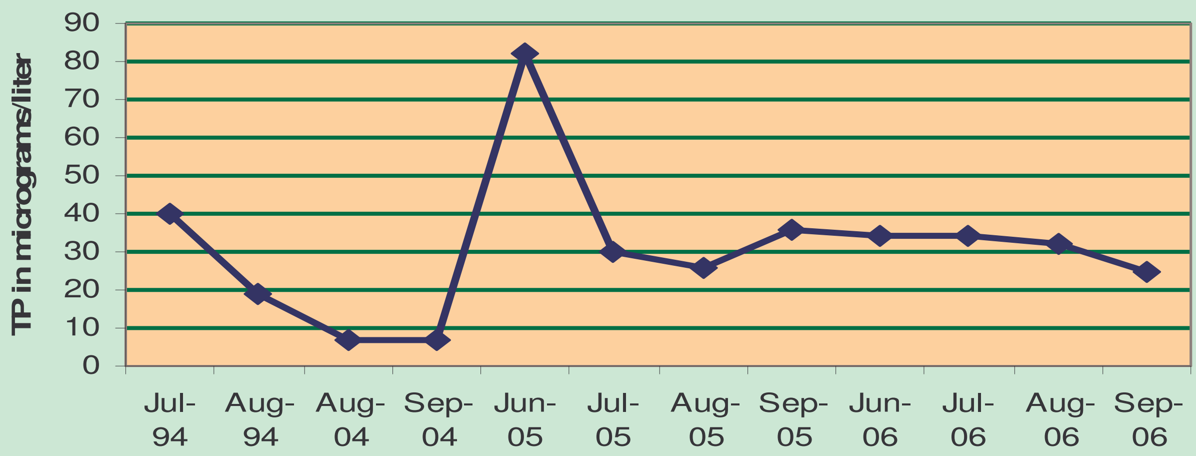
Phosphorus is not an element that occurs in high concentration naturally, so any lake that has significant phosphorus readings must have gotten that phosphorus from outside the lake or from internal loading. Some phosphorus is deposited onto the lake from atmospheric deposition, especially from soil or other particles in the air carrying phosphorus. A lake that includes a flooded wetland area may have a significant amount of phosphorus being released during the flushing of the wetland area. Phosphorus may accumulate in sediments from dying animals, dying aquatic plants and dying algae. If the bottom of the lake becomes anoxic (oxygen-depleted), chemical reactions may cause phosphorus to be released to the water column.

Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For an impoundment lake like Arkdale Lake, a total phosphorus concentration below 30 micrograms/liter tends to prevent nuisance algal blooms. Arkdale Lake's growing season (June-September) surface average total phosphorus level of 29.5 micrograms/liter is close to the level at which nuisance algal blooms can be expected (and are often found on Arkdale Lake).

Since phosphorus is usually the limited factor, measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth.

The 2004-2006 summer average phosphorus concentration in Arkdale Lake was 29.5 ug/liter. This places Arkdale Lake in the "fair" water quality section for impoundments, and in the "mesotrophic" level for phosphorus.

Figure 16: Eplimnetic Total Phosphorus Levels



As the above graph (Figure 16) indicates, the growing season total phosphorus levels have varied and usually registered above the level recommended to avoid nuisance algal blooms. Except for a spike in June 2005, the eplimnetic total phosphorus levels since August 2004 stayed below 40 micrograms/liter. But since this is above levels recommended to avoid algal blooms, phosphorus should continue to be monitored and steps should be taken to reduce the phosphorus levels in the lake.

Groundwater testing of various wells around Arkdale Lake was done by Adams County LWCD and included a test one year for total phosphorus levels in the groundwater coming into the lake. The average TP level in the wells tested 37 micrograms/liter, somewhat higher than the lake surface water results. Some of this phosphorus may also seep into Arkdale Lake.

Land use plays a major role in phosphorus loading. A key component of the computer models used is the phosphorus budget, that is, the estimated amount of phosphorus delivered to the lake from each land use type annually. The land uses that contribute the most phosphorus are non-irrigated agriculture and residences. Using the current land use data, as well as phosphorus readings from 2004 through 2006 water sampling, a phosphorus loading prediction model was run for Arkdale Lake. The current results are shown in the table below:

Figure 17: Current Phosphorus Loading by Land Use

Most Likely Phosphorus Loading	Current lbs/yr	% total
Agriculture--Non Irrigated	121.34	6.4%
Agriculture--Irrigated	51.75	2.7%
Government	1.78	0.1%
Residential--medium density	11.60	0.6%
Residential--rural density	3.57	0.2%
Lake (atmosphere deposition)	2.68	0.2%
Other Water	12.49	0.7%
Woodland	16.06	0.9%
groundshed	371.16	19.5%
septic	5.89	0.3%
Big Roche a Cri Lake Watershed	1302.79	68.4%
	1901.10	100.0%

Phosphorus deposits such as that from flooded wetlands or from atmospheric deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Circumstances such as increased impervious surface, lawns mowed to water's edge, disturbance of shore areas, improperly-functioning septic systems and removal of native vegetation can greatly increase the volume and content of runoff—and thus increase the volume of phosphorus entering the lake. Many of these practices can also increase the concentration of phosphorus entering the lake, by runoff or other methods of entry.

The models were run using not only the current known phosphorus readings in the lake, but also representing decreases or increases of human-controlled phosphorus input by 10%, 25%, and 50%. The figures may not seem like much---until you calculate that one pound of phosphorus can result in up to 500 pounds of algae. A 10% reduction in these three areas could result in up to 225,240 pounds less of algae per year!

Figure 18: Impact Reductions in Phosphorus Loading

	-10%	-25.00%	-50%
Agriculture--Non Irrigated	109.21	91.0044	60.6696
Agriculture--Irrigated	46.57	38.8107	25.8738
Government*	2.00	2.00	2.00
Residential--medium density	10.44	8.69895	5.7993
Residential--rural density	3.21	2.6766	1.7844
Lake (atmosphere deposition)*	2.68	2.68	2.68
Other Water*	12.49	12.49	12.49
Woodland*	16.06	16.06	16.06
groundshed	70.15	58.45	38.97
septic	5.30	4.41639	2.94426
upstream watershed (BRC)	1172.51	1172.51	1172.51
Total in pounds	1450.62	1409.80	1341.78

Looking at this issue in terms of how much phosphorus readings in the lake might change in-lake levels, based on the computer modeling, perhaps makes it clearer. Figure 17 showed the surface summer (June-September) mean phosphorus levels for Arkdale Lake since 1994. The overall average for those 12 years was 38.97 micrograms/liter.

Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% would improve Arkdale Lake water quality by 2 to 10 micrograms of phosphorus/liter; a 25% reduction would save 6 to 19 micrograms/liter (see Figure 19). Reductions of 25% could put the lake low enough in total phosphorus levels that algal blooms would be greatly reduced. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Arkdale Lake's health for future generations.

Figure 19: Impact of Reduction on In-lake Phosphorus

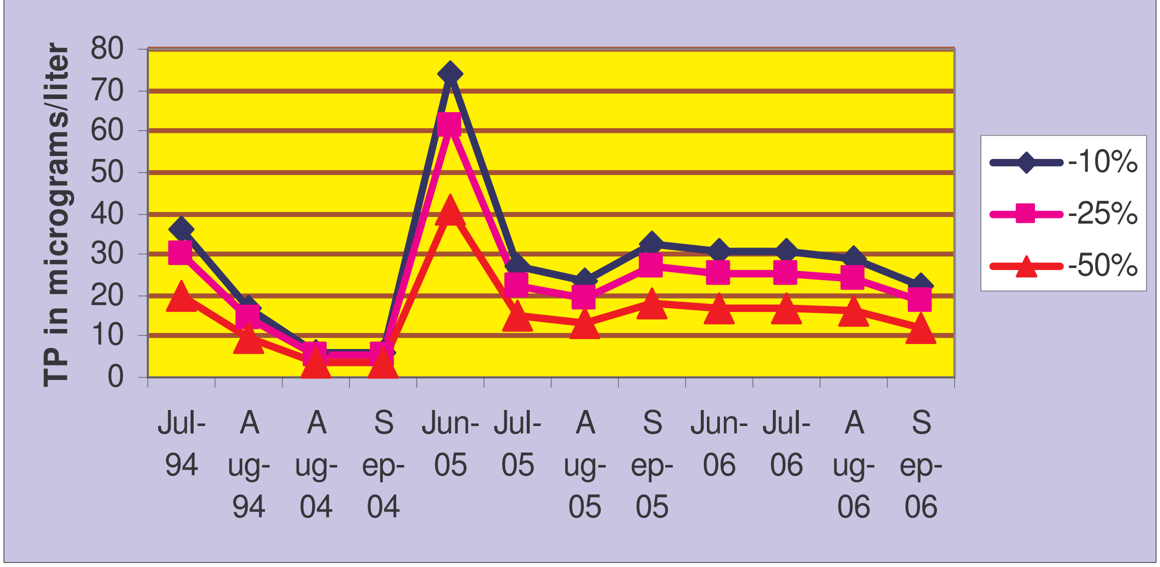


Figure 20: Arkdale Lake in Late Winter*

***photo courtesy of Doug Wellumson**
Arkdale Lake resident

Water Clarity

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Arkdale Lake in 2004-2006 was 5.17 feet. This is fair water clarity, putting Arkdale Lake into the "mesotrophic" category for water clarity.

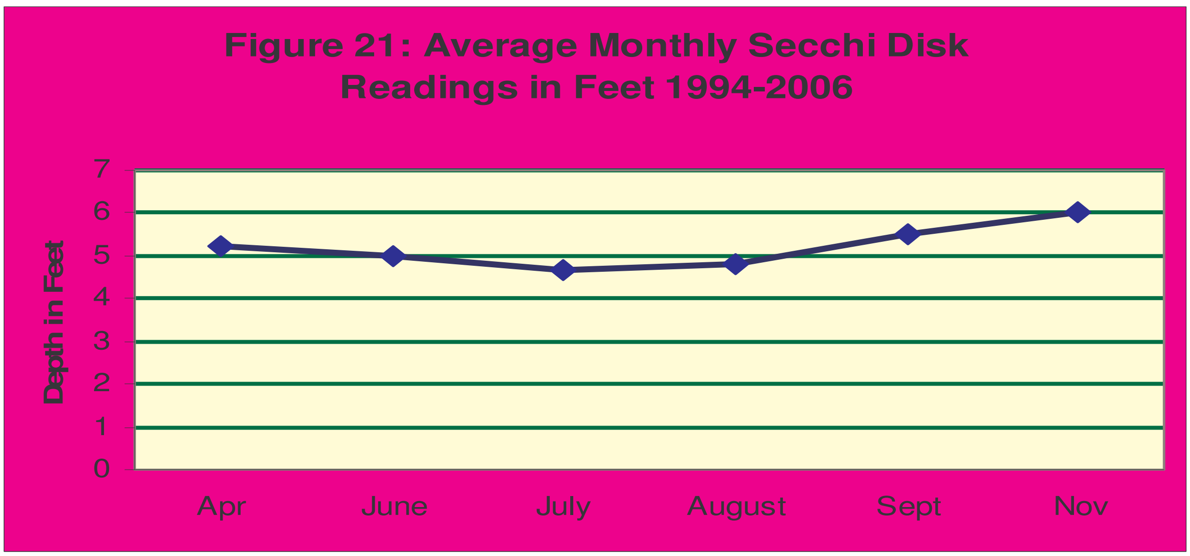


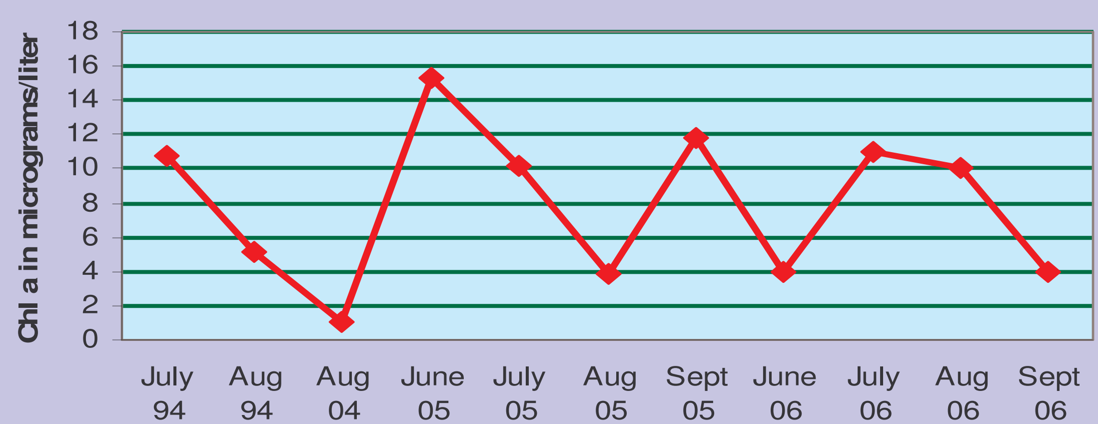
Figure 22: Photo of Testing Water Clarity with Secchi Disk

Chlorophyll a

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll a in lake water depends greatly on the amount of algae present; therefore, chlorophyll-a levels are commonly used as a water quality indicator. The 2004-2006 summer (June-September) average chlorophyll concentration in Arkdale Lake was 7.5 ug/liter Such an algae concentration places Arkdale Lake at the "good" level for chlorophyll a results.

Chlorophyll-a averages have varied considerably since 1994, the first year for which records were found, and have remained fairly low during the time that Adams County LWCD was monitoring the lake.

Figure 23: Chlorophyll a in Arkdale Lake



Dissolved Oxygen

Oxygen dissolved in the water is essential to all aerobic aquatic organisms. The oxygen in a lake comes from the atmosphere and from the process of photosynthesis. Aquatic plants and algae consume carbon dioxide and respirate oxygen back into the lake water. The distribution of oxygen within a lake is affected by many factors, including water circulation, water stratification, winds or storms, air temperature; water temperature, nutrient availability, and the density and location of algae and/or aquatic plants.

Low oxygen during the summer in the bottom waters of a lake can occur, but is not common in lakes as shallow as Arkdale Lake. During the summers of 2004, 2005 and 2006, dissolved oxygen levels didn't usually go below levels 5 mg/l, the appropriate level for good fish survival. The charts (Figures 48a, b, c) below show the annual (2004-2006) variations in dissolved oxygen levels in milligrams/liter, depth in feet and months of the year:

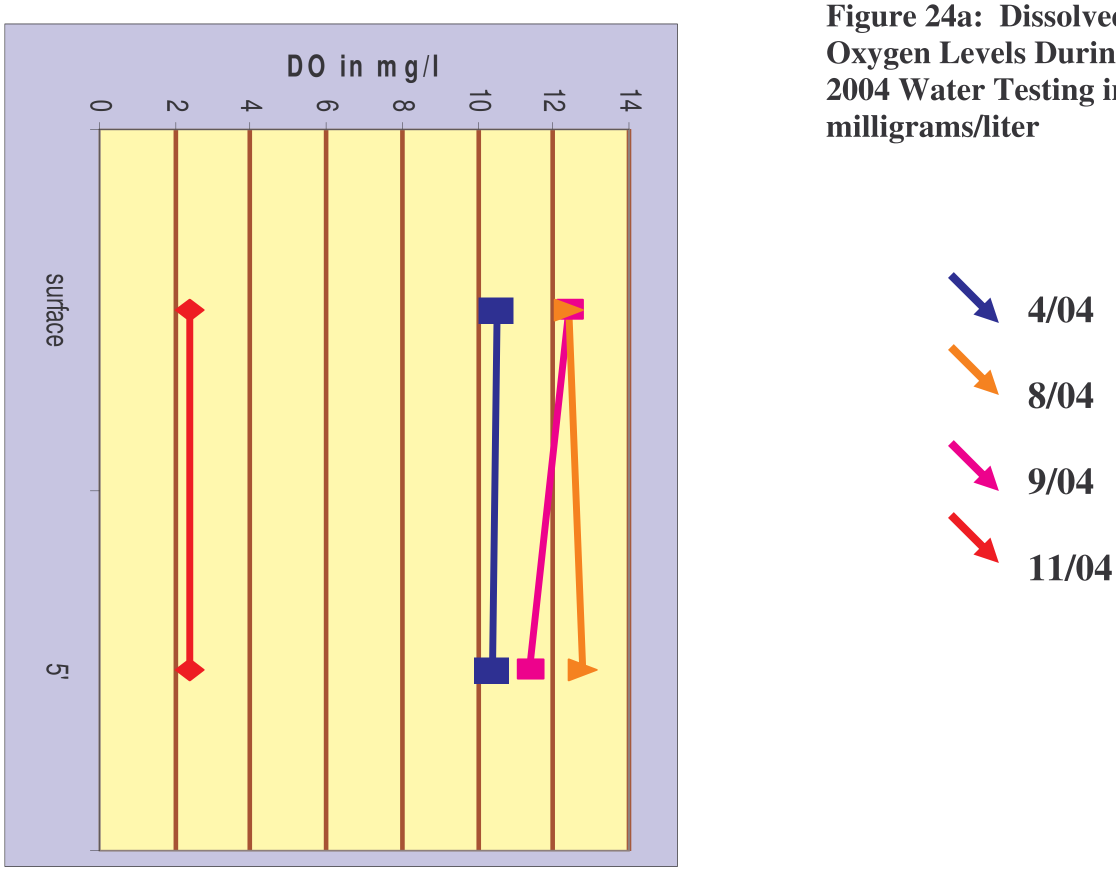
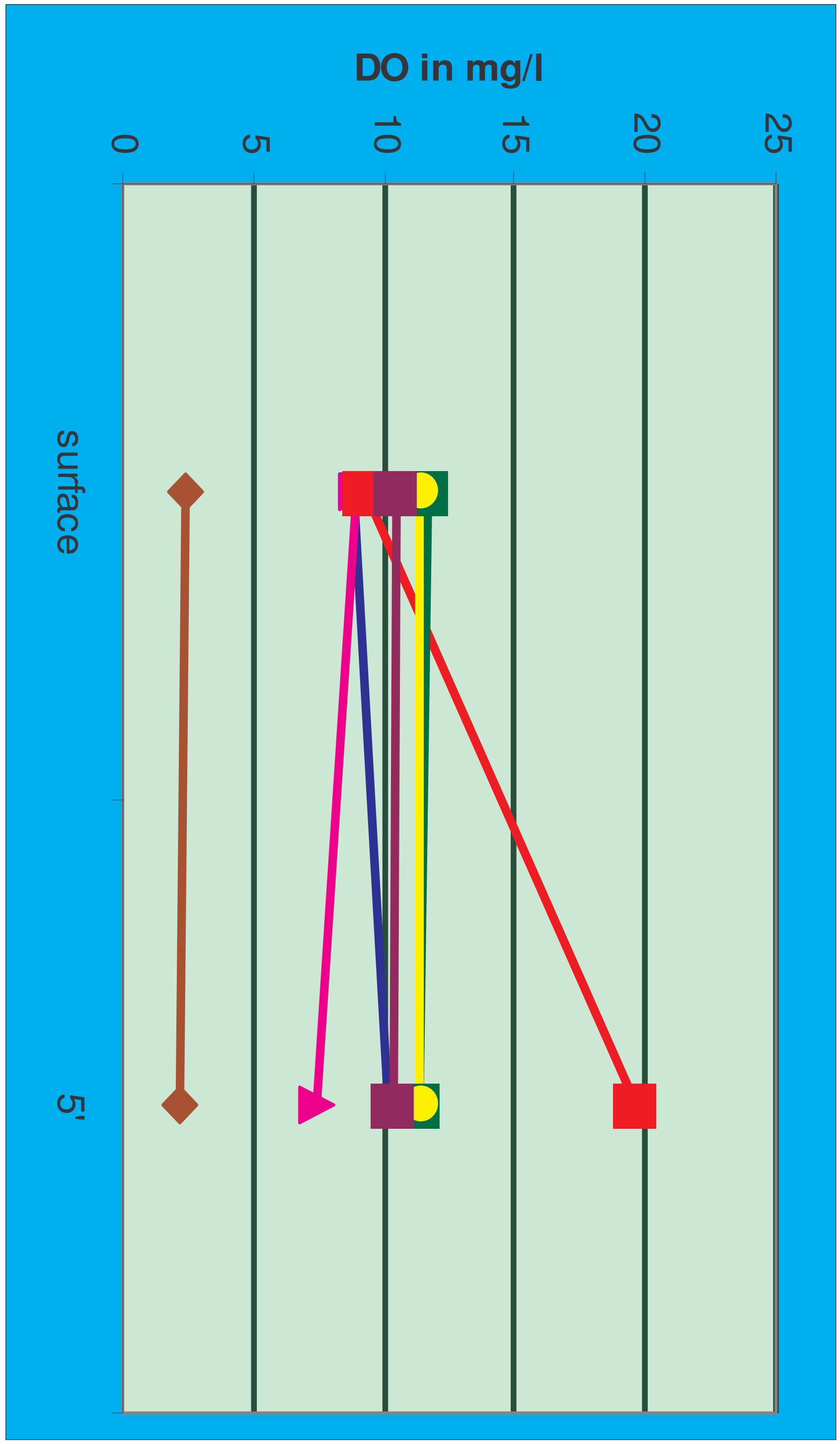


Figure 24a: Dissolved Oxygen Levels During 2004 Water Testing in milligrams/liter

Figure 24b: Dissolved Oxygen Levels During 2005 Water in milligrams/liter



4/05

6/05

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8/05

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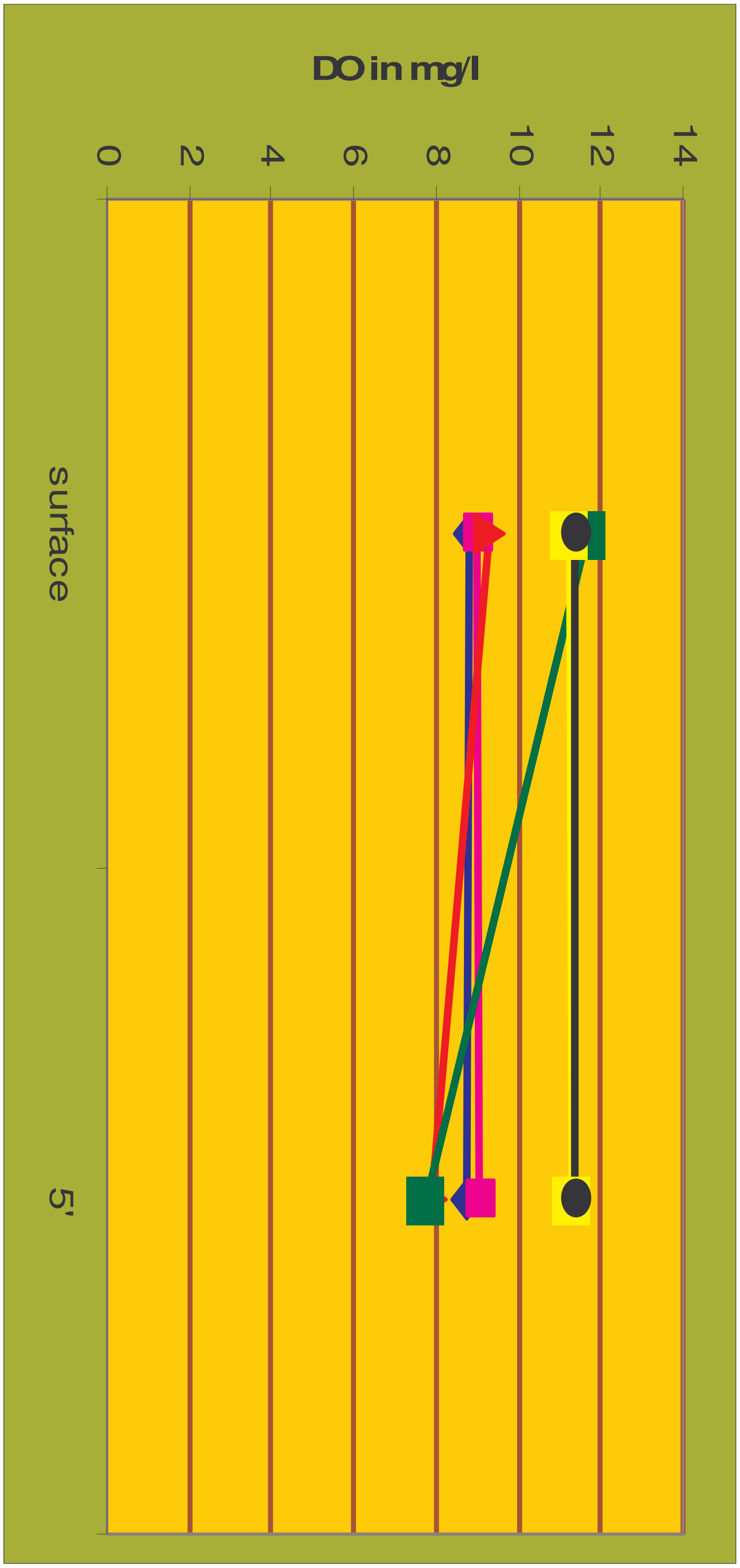


Figure24c: Dissolved Oxygen Levels During 2006 Water Testing in milligrams/liter

4/06

6/06

7/06

8/06

9/06

9/06

In deeper lakes, when the surface waters have cooled in autumn and water density throughout the water column is the same, the water column mixes vertically, a process known as "fall turnover." Since Arkdale Lake is such a shallow lake, it does not stratify and thus does not turnover in either the spring or fall.

Further, since flowing stream goes through the south side of Arkdale Lake, some open water is common throughout the winter on part of the lake. This probably allows oxygen levels to stay elevated—even the winter dissolved oxygen readings at Arkdale Lake were 7.9 mg/l, over the amount needed by fish.

Figure 25: Photo of a Lake with Algal Bloom

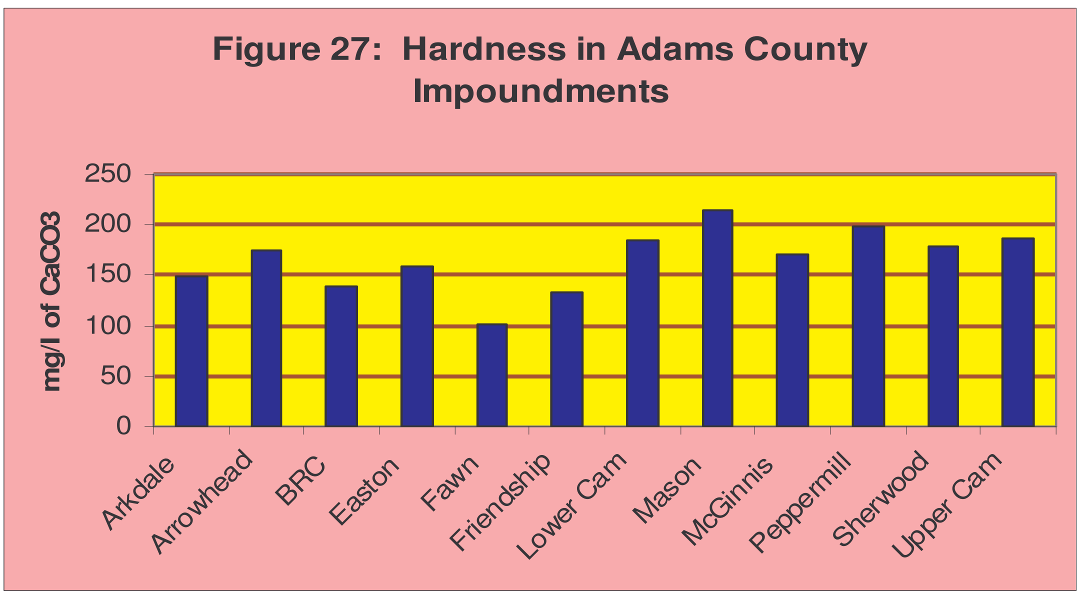
Water Hardness, Alkalinity and pH

Testing done by Adams County LWCD on Arkdale Lake included annual testing for water alkalinity and water hardness. Hardness and alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water & these materials.

Level of Hardness	Mg/l CaCO3
SOFT	0-60
MODERATELY HARD	61-120
HARD	121-180
VERY HARD	>180

Figure 26: Levels of Hardness in Mg/l of Calcium Carbonate

One method of evaluating hardness is to test the water for the amount of calcium carbonate (CaCO3) it contains. The surface water of all of the public access lakes in Adams County have water that is moderately hard to very hard, whether they are impoundments (man-made lakes) or natural lakes. In 2005 and 2006, random samples were also taken of wells around Arkdale Lake to measure the hardness of the water coming into the lake through groundwater. Hardness in the groundwater ranged from 108 (moderately hard) to 232 (very hard), with an average of 166.5 mg/l. The hardness in both surface and groundwater is likely due to the underlying bedrock in Adams County, which is mostly sandstone with pockets of dolomite and shale.



As the graph (Figure 27) shows, Arkdale Lake surface water testing results showed "very hard" water (average 149 mg/l CaCO3), although Arkdale Lake's hardness is less than the overall hardness average impoundments in Adams County of 166 mg/l of Calcium Carbonate. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. "Acid rain" has long been a problem with lakes that had low alkalinity level and high potential sources of acid deposition.

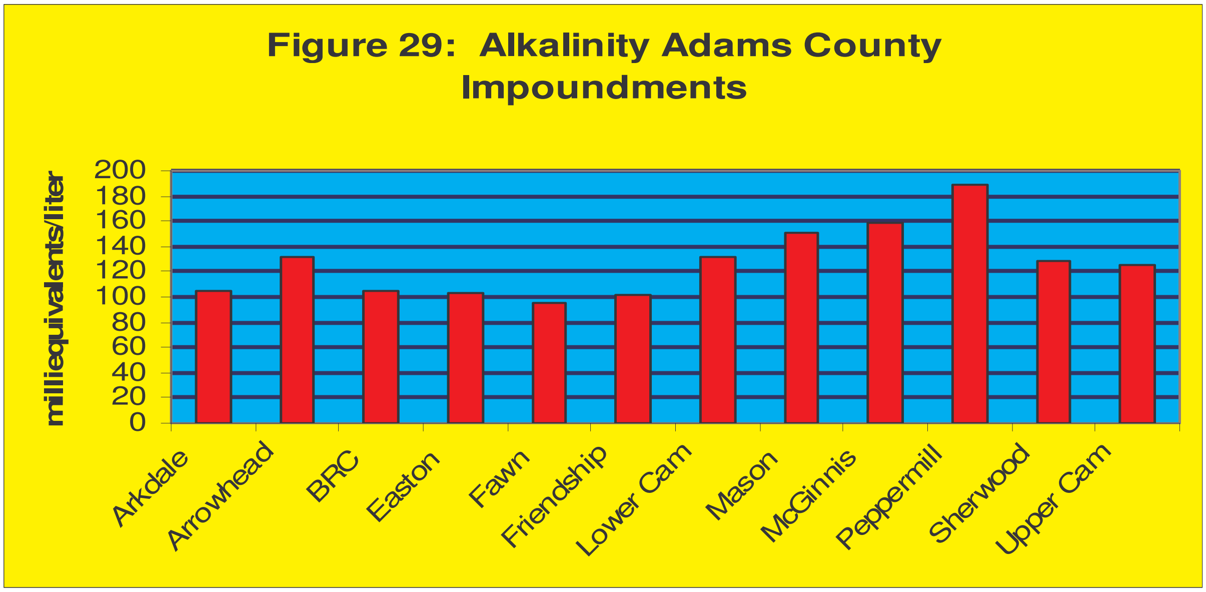
Acid Rain Sensitivity	ueq/l CaCO3
High	0-39
Moderate	49-199
Low	200-499
Not Sensitive	>500

Figure 28: Acid Rain Sensitivity

Well water testing results ranged from 60 ueq/l to 180 ueq/l in alkalinity, with an average of 123 ueq/l. This is higher than the surface water average of 105. Arkdale Lake's potential sensitivity to acid rain is moderate, but luckily for Adams County, the acid deposition rate is very low, probably due to the little industrialization in the county.

Alkalinity also affects the pH level of lake water. The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid bog lakes to 8.4 in hard water, marl lakes.

Some of the minerals that become available under low pH, especially the metals aluminum, zinc and mercury, can inhibit fish reproduction and/or survival. Even what seems like a small variance in pH can have large effects because the pH scale is set up so that every 1.0 unit change increases acidity tenfold, i.e., water with a pH of 7 is 10 times more acid than water with pH of 8. Mercury and aluminum are not only toxic to many kinds of wildlife; they can also be toxic to humans, especially those that eat tainted fish.



The testing occurring from 2004-2006 also included regular monitoring of the pH at several depths in Arkdale Lake. As is common in the lakes in Adams County, Arkdale Lake has pH levels starting at just over neutral (7.2) at 50' depth and increasing in alkalinity as the depth gets less, until the surface water pH averages 7.54. A lake's pH level is important for the release of potentially harmful substances and also affects plant growth, fish reproduction and survival. Most plants grow best at pH levels between 5.5 and 8.

More importantly for many lakes, fish reproduction and survival are very sensitive to pH levels. The chart below indicates the effect of pH levels under 6.5 on fish (Figure 30):

Figure 30: Effects of pH Levels on Fish

Water pH	Effects
6.5	walleye spawning inhibited
5.8	lake trout spawning inhibited
5.5	smallmouth bass disappear
5.2	walleye & lake trout disappear
5	spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	perch spawning inhibited
3.5	perch disappear
3	toxic to all fish

No pH levels taken in Arkdale Lake between 2004-2006 fell below the pH level that inhibits walleye reproduction. A lake with a neutral or slightly alkaline pH like Arkdale Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Arkdale Lake. Arkdale Lake has a good pH level for fish reproduction and survival.

Figure 31: Abundant Fish in Arkdale Lake: top Northern Pike (*Esox lucius linnaeus)* and bottom White Sucker *(Catostomus commersoni)*

Other Water Quality Testing Results

CALCIUM and MAGNESIUM: Calcium is required by all higher plants and some microscopic lifeforms. Magnesium is needed by chlorophyllic plants and by algae, fungi and bacteria. Both calcium and magnesium are important contributors to the hardness of a lake's waters. Magnesium elevated about 125 mg/l may have a laxative effect on some humans. Otherwise, no health hazards to humans and wildlife are known from calcium and magnesium. The average Calcium level in Arkdale Lake's water during the testing period was 33.76 mg/l. The average Magnesium level was 14.58 mg/l. Both of these are low-level readings.

CHLORIDE: Chloride does not affect plant and algae growth and is not known to be harmful to humans. It isn't common in most Wisconsin soils and rocks, so is usually found only in very low levels in Wisconsin lakes. However, the presence of a significant amount of chloride over a period of time indicates there may be negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. An increased chloride level is thus an indication that too many nutrients are entering the lake, although the level has to be evaluated compared to the natural background data for chloride. The average chloride level found in Arkdale Lake during the testing period was 7.42 mg/l, above the natural level of chloride in this area of Wisconsin. Further investigation as to the cause of such elevations needs to be performed.

NITROGEN: Nitrogen is necessary for plant and algae growth. A lake receives nitrogen in various forms, including nitrate, nitrite, organic, and ammonium. In Wisconsin, the amount of nitrogen in a lake's water often corresponds to the local land use. Although some nitrogen will enter a lake through rainfall from the atmosphere, that coming from land use tends to be in higher concentrations in larger amounts, coming from fertilizers, animal and human wastes, decomposing organic matter, and surface runoff. For example, the growth level of the exotic aquatic plant, Eurasian Watermilfoil (*Myriophyllum spicatum*) has been correlated with fertilization of lake sediment by nitrogen-rich spring runoff.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Arkdale Lake combination spring levels from 2004 to 2006 averaged 2.99 mg/l, far above the .3 mg/l predictive level for algal blooms. Arkdale Lake has a significant ongoing problem with large and frequent algal blooms during the growing season.

SODIUM AND POTASSIUM: These elements occur naturally only in low levels in Wisconsin waters and soils. Their presence may indicate human-caused pollution. Sodium is found with chloride in many road salts and fertilizers and is also found in human and animal waste. Potassium is found in many fertilizers and also found in animal waste. The level of these two is generally not useful as a specific pollution indicator, but increasing levels or one or both of these elements can indicate possible contamination from damaging pollutants. High levels of sodium have also been found to influence the development of a large population of cyanobacteria, some of which can be toxic to animals and humans. Some health professionals have suggested that sodium levels over 20 mg/l may be harmful to heart and kidney patients if ingested.

Both sodium and potassium levels in Arkdale Lake are very low: the average sodium level was 2.2 mg/l; the average potassium reading 1.68 mg/l.

SULFATE: In low-oxygen waters (hypoxic), sulfate can combine with hydrogen and becomes the gas hydrogen sulfate, which smells like rotten eggs and is toxic to most aquatic organisms. Sulfate levels can also affect the metal ions in the lake, especially iron and mercury, by binding them up, thus removing them from the water column.

To prevent the formation of hydrogen sulfate, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Arkdale Lake sulfate levels averaged 13.17 mg/l during the testing period, above the level for hydrogen sulfate formation, but below the health advisory level.

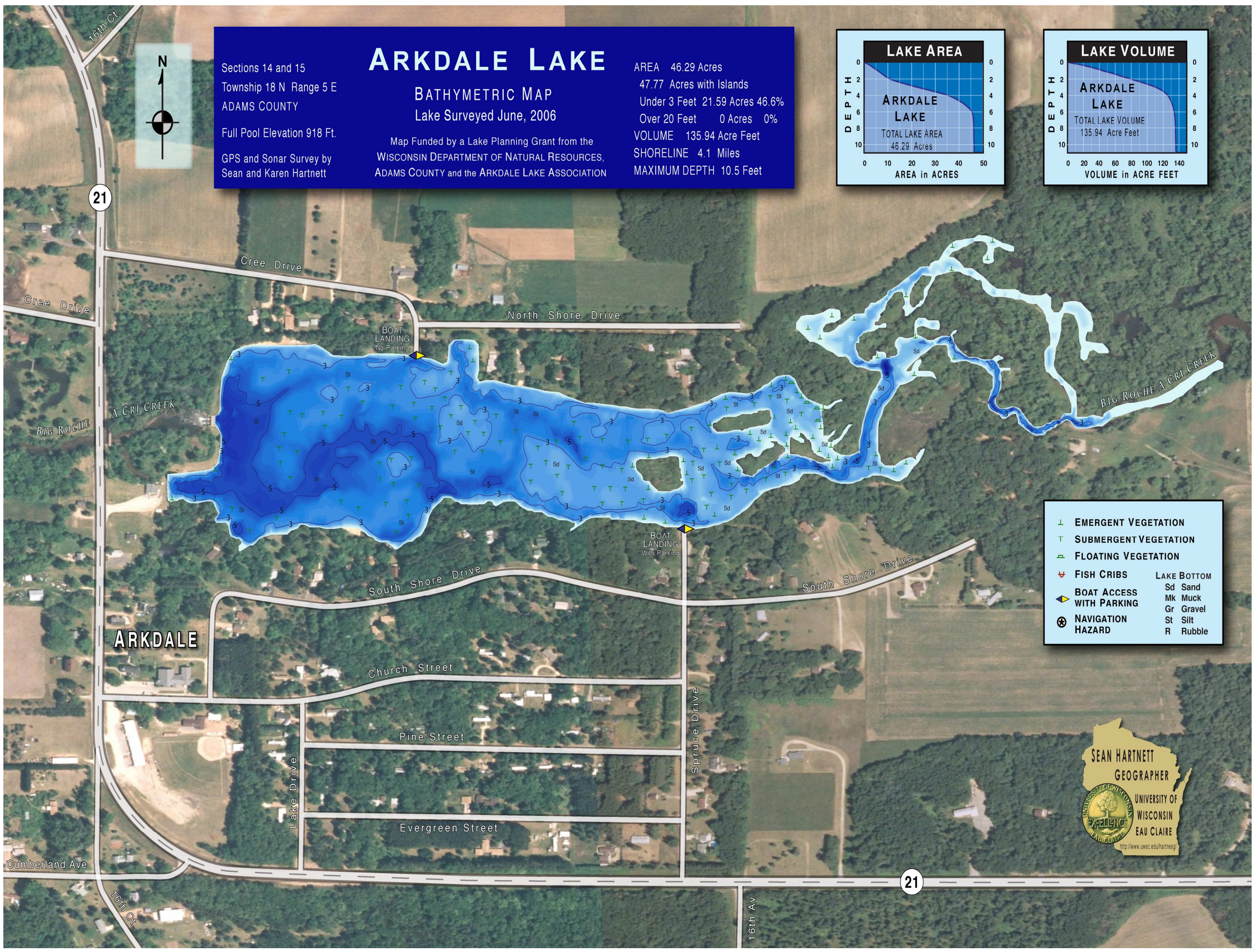
TURBIDITY: Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Turbid water may mask the presence of bacteria or other pollutants because the water looks murky or muddy. In general, turbidity readings of less than 5 NTU are best. Very turbid waters may not only smell, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Arkdale Lake's waters were 2.2 NTU in 2004, 2.54 NTU in 2005, and 2.91 NTU in 2006—all below the level of concern.

Figure 32: Examples of Very Turbid Water

HYDROLOGIC BUDGET

According to date gathered for a recent bathymetric (depth) map, Arkdale Lake is 46.29 surface acres, and the volume of the lake is 135.94 acre-feet. The mean depth is 3.37 feet. The maximum depth is 10.5 feet.

Figure 33: Bathymetric Map of Arkdale Lake

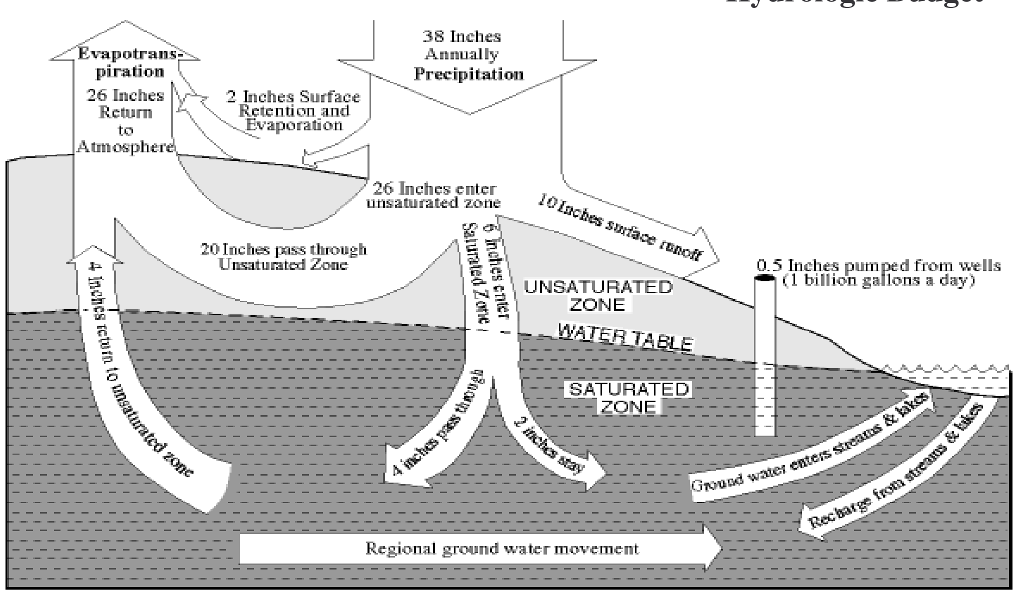


A "hydrologic budget" is an accounting of the inflow to, outflow from and storage in a hydrological unit (such as a lake). "Residence time" is the average length of time particular water stays within a lake before leaving it. This can range from several days to years, depending on the type of lake, amount of rainfall, and other factors. "Flushing rate" is the time it takes a lake's volume to be replaced. "Annual runoff volume", as used in WiLMS, is the total water yield from the drainage area reaching the lake. The "drainage area" is the amount of area (in acres) contributing surface water runoff and nutrients to the lake. The "areal water load" is the total annual flow volume reaching the lake divided by the surface area of the lake. "Hydraulic loading" is the total annual volume of all water sources (including precipitation, non-point sources & point sources) loading into the lake.

Using the data gathered from historical testing and that done by the Adams County LWCD from 2004-2006, the WiLMS model calculated the tributary drainage area for Arkdale Lake as 23236 acres. The average unit runoff for Adams County in the Arkdale Lake area is 9.4 inches. WiLMS determined the expected annual runoff volume as 18201.5 acre-feet/year. Anticipated annual hydraulic loading is 22907.5 acre-feet/year. Areal water load is 416.5 feet/year.

In an impoundment lake like Arkdale Lake, a significant portion of the water and its nutrient load running through it from the impounded creek tend to flush through the lake and continue downstream—in Arkdale Lake's case, modeling estimates a water residence of 0/01 feet/year. The calculated lake flushing rate is 123.56 1/year. Water and its load flow through Arkdale Lake fairly quickly.

Figure 34: Example of Hydrologic Budget



TROPHIC STATE

The trophic state of a lake is one measure of water quality, basically defining the lake's biological production status (see Figure 35). **Eutrophic lakes** are very productive, with high nutrient levels, frequent algal blooms and/or abundant aquatic plant growth. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small populations of fish. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; often with a more varied fishery than either the eutrophic or oligotrophic lakes. In comparing water quality testing results with the prediction from the computer modeling of this modeling with the actual figures outlined above, the actual Trophic State of Arkdale Lake is what was predicted from the modeling. Modeling results predicted that the overall TSI for Arkdale Lake would be **52**. This score places Arkdale Lake's overall TSI at about average for impoundment lakes in Adams County (52.83).

Figure 35: Trophic Status Table

Score	TSI Level Description
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

Arkdale Lake = 52

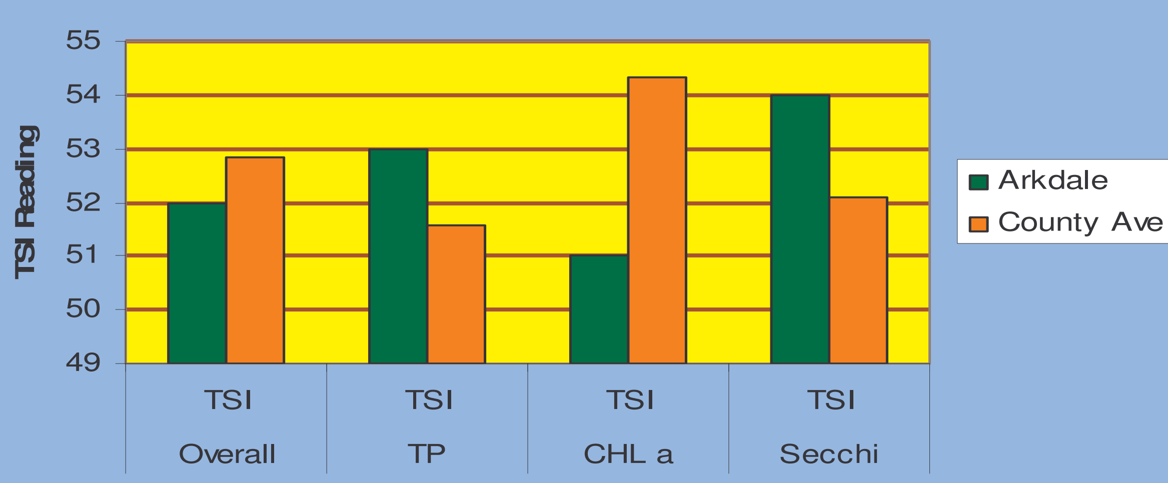
Phosphorus concentration, chlorophyll-a concentration and water clarity data are collected and combined to determine a trophic state. As discussed earlier, the average summer epilimnetic total phosphorus for Arkdale Lake was 29.5 micrograms/liter. The average summer chlorophyll-a concentration was 7.5 milligrams/liter. Growing season water clarity averaged a depth of 5.17 feet. Figure 36 shows where each of these measurements from Arkdale Lake fall in trophic level.

Figure 36: Arkdale Lake Trophic Status Overview

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(mg/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	**10 to 30**	**5 to 10**	6 to 8
	Fair	30 to 50	10 to 15	**5 to 6**
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Arkdale Lake		**29.5**	**7.5**	**5.17**

These figures show that Arkdale Lake has fair to good levels overall for the three parameters often used to described water quality: Secchi disk depths; average TP for the growing season; and chlorophyll a levels. It is normal for all of these values to fluctuate during a growing season. However, they can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Arkdale Lake is below the county impoundments average for overall TSI levels—which is positive, since with TSI levels, the lower the better.

Figure 37: TSI for Arkdale Lake



IN-LAKE HABITAT

Aquatic Plants

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in improving water quality, providing valuable habitat resources for fish and wildlife, resisting invasions of non-native species and checking excessive growth of the most tolerant species.

An aquatic plant survey was done on Arkdale Lake in the summer of 2005 by staff from the Adams County LWCD. Its trophic state should support moderate to dense plant growth and occasional algal blooms. The aquatic plant survey was generally in keeping with this prediction. Filamentous algae were common in Arkdale Lake, present at least 43%, of the sites and found even in the over 5' depth zone.

Despite the sometime limiting effect of sand sediments on aquatic plant growth, 89.3% of the lake bottom is vegetated, suggesting that even the sand sediments in Arkdale Lake hold sufficient nutrients to maintain aquatic plant growth. Due to the shallow depth, sunlight can encourage plant growth at all depths in the lake.

The 0 to 1.5 feet depth zone and the 1.5 feet to 5 feet were nearly tied in frequency of growth. The quality of the aquatic plant community in Arkdale Lake is below average for Wisconsin lakes and for lakes in the North Central Hardwood region, as measured by the AMCI. Structurally, it does contain emergent plants, rooted plants, floating plants and one rooted plant with floating leaves. However, the community is characterized by plants that tolerate a high amount of disturbance and abundant filamentous algae. Submergent and free-floating species were especially abundant.

The dominant plant in the lake was *Vallisneria americana* (wild celery), a rooted plant. *Wolffia* spp. (common watermeal, a floating plant) was sub-dominant. The next closest plant in abundance was *Potamogeton zosteriformis* (flat-stemmed pondweed, a submerged rooted plant), while *Spirodela polyrhiza* (large duckweed, a free-floating plant) was also fairly dense. Nearly 86% of the sample sites had rooted aquatic plants, and all three depth zones had free-floating plants present.

Found in all three depth zones were *Vallisneria americana* and *Wolffia* spp. *Iris versicolor* (blue flag iris, a rooted plant) was sub-dominant in the 0-1.5' depth, while *Ceratophyllum demersum* (coontail, a rooted plant) and *Elodea canadensis* (common waterweed, a rooted plant) were sub-dominant in the 1.5'-5' depth zone. *Myriophyllum spicatum*, an exotic rooted plant, was sub-dominant with *Ceratophyllum demersum* in the over 5' depth zone.

Figure 38: Arkdale Lake Aquatic Plant Species 2005

Scientific Name	**Common Name**
Emergent Species	
Carex spp	sedge
Iris versicolor	northern blue flag
Sagittaria latifolia	common arrowhead
Sparganium eurycarpum	common burreed
Free-Floating Species	
Lemna minor	small duckweed
Spirodela polyrhiza	large duckweed
Wolffia spp	watermeal
Floating-Leaf Species	
Nymphaea odorata	white water lily
Submergent Species	
Ceratophyllum demersum	coontail
Elodea canadensis	common waterweed
Myriphyllum spicatum	Eurasian watermilfoil
Najas guadelupensis	Southern naiad
Potamogeton amplifolis	large-leaf pondweed
Potamogeton zosteriformis	flatstem pondweed
Vallisneria americana	water celery
Plant-like Algae	
Chara spp	muskgrass

The Simpson's Diversity Index for Arkdale Lake was .88, suggesting good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The Aquatic Macrophyte Community Index (AMCI) for Arkdale Lake is 53. This is below average for Central Wisconsin Hardwood Lakes and Impoundments, suggesting an aquatic plant community of below average quality. The aquatic plant community in Arkdale Lake is in the category of those most tolerant of disturbance, likely from a high amount of disturbance compared to other Wisconsin lakes.

The presence of the invasive Eurasian Watermilfoil is a significant factor. Currently, its density and relative frequency doesn't establish it as dominant among Arkdale Lake's aquatic plant community, but its tenacity and ability to spread to large areas fairly quickly make it a danger to the diversity of Arkdale Lake's aquatic plant community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservatism for Arkdale Lake was 4.71. This puts it in the lowest quartile for Wisconsin Lakes (average 6.0) and for lakes in the North Central Hardwood Region (average 5.6). The aquatic plant community in Arkdale Lake is in the category of those most tolerant of disturbance, probably due to selection by a series of past disturbances.

The Floristic Quality Index of the aquatic plant community in Arkdale Lake of 17.639 is below average for Wisconsin Lakes (average 22.2) and the North Central Hardwood Region (average 20.9). This again indicates that the plant community in Arkdale Lake is farther from an undisturbed condition than the average lake in Wisconsin overall and in the North Central Hardwood Region. In other words, the aquatic plant community in Arkdale Lake has been impacted by a high amount of disturbance.

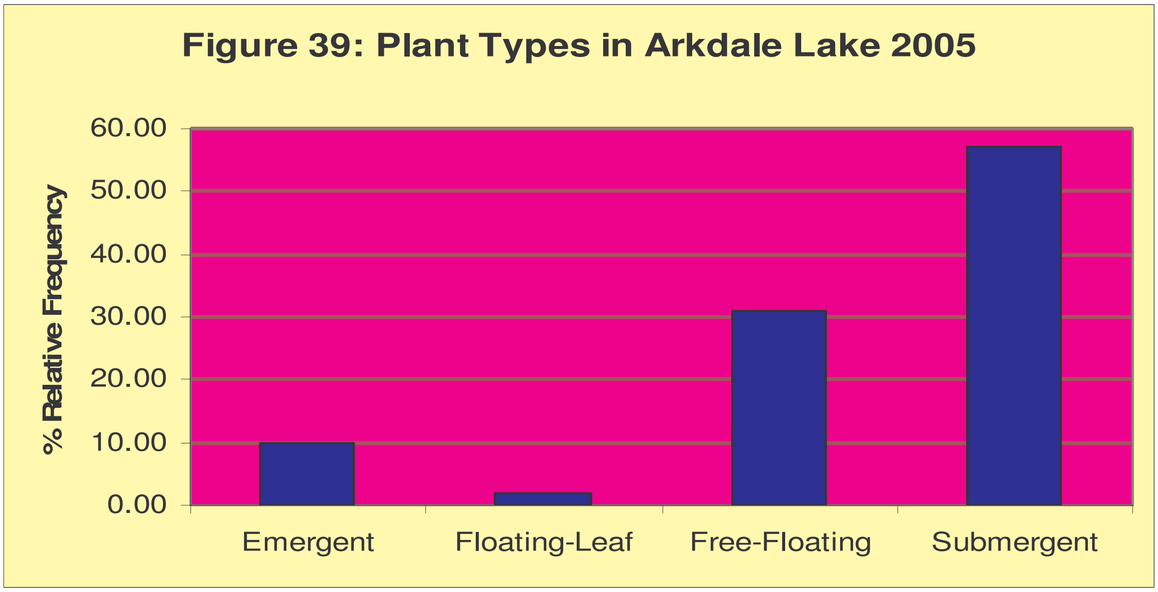


Figure 40a: Distribution of Emergent Plants in Arkdale Lake 2005

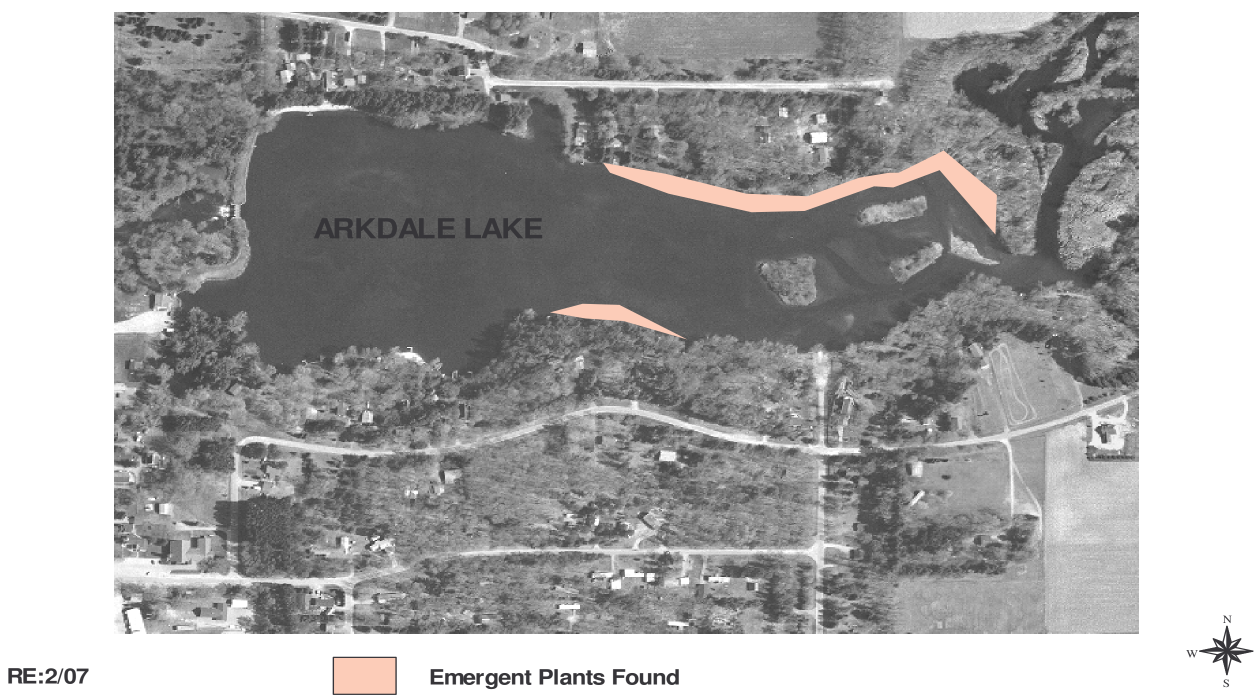


Figure 40b: Floating-Leaf Aquatic Plants in Arkdale Lake 2005

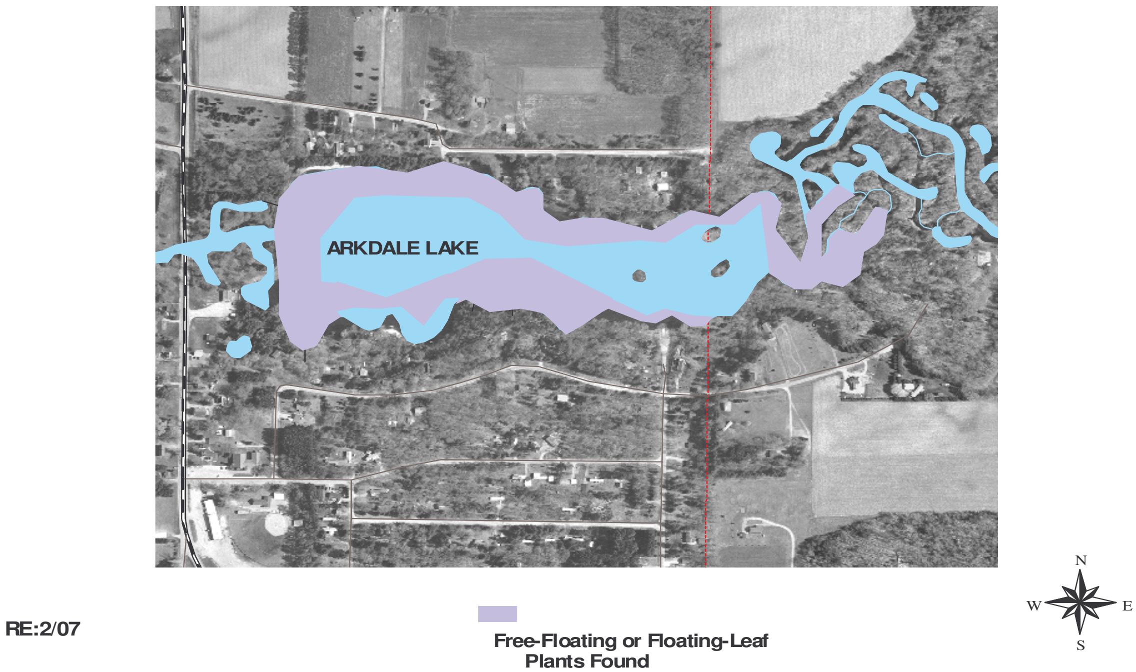
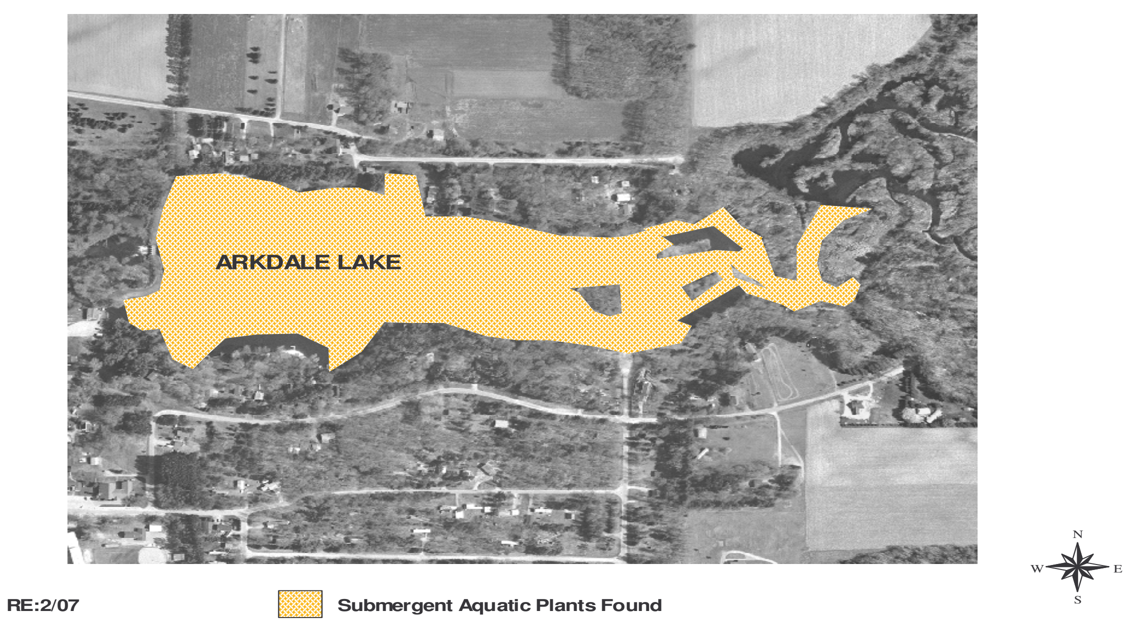


Figure 40c: Submergent Aquatic Plants in Arkdale Lake 2005



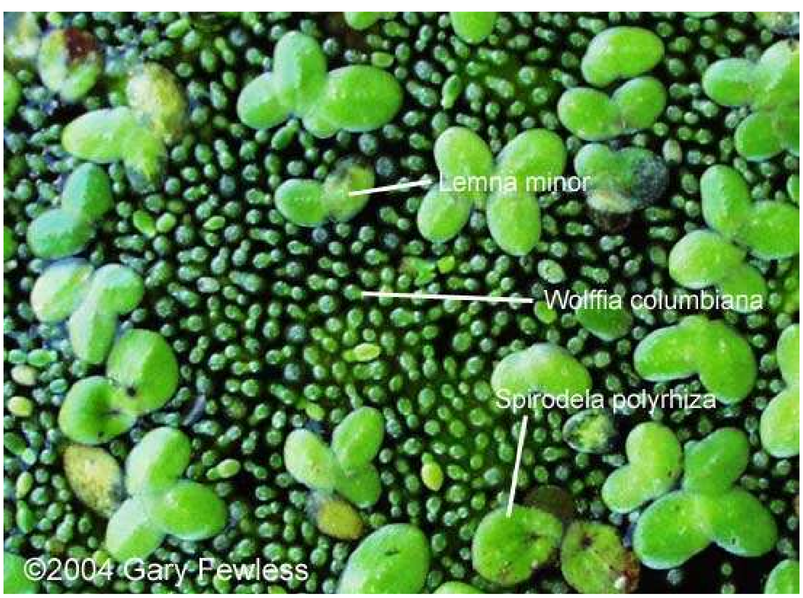
Vallisneria americana
(Wild Celery)

Potamogeton zosteriformis
(Flat-Stem Pondweed)

Figure 41: Most Common Native Aquatic Species in Arkdale Lake

Lemna minor
(Small Duckweed)

***Wolffia* etc**
(Common Watermeal)



Aquatic Invasives

Eurasian Watermilfoil was introduced in Arkdale Lake at an unknown time, probably through one of the public boat ramps. In the past, Arkdale Lake Association did some minimal mechanical harvesting in the lake, but it has not yet developed an approved mechanical harvesting plan. In July 2005, Eurasian Watermilfoil was the fourth most commonly occurring aquatic species. The Arkdale Lake Association expects to develop a more specific management plan during 2008 when it drafts a lake management plan. Starting in 2007, a citizen monitoring group was trained and carried out monitoring the Eurasian Watermilfoil population.

Figure 42: Distribution of Exotic Aquatic Plants in 2005

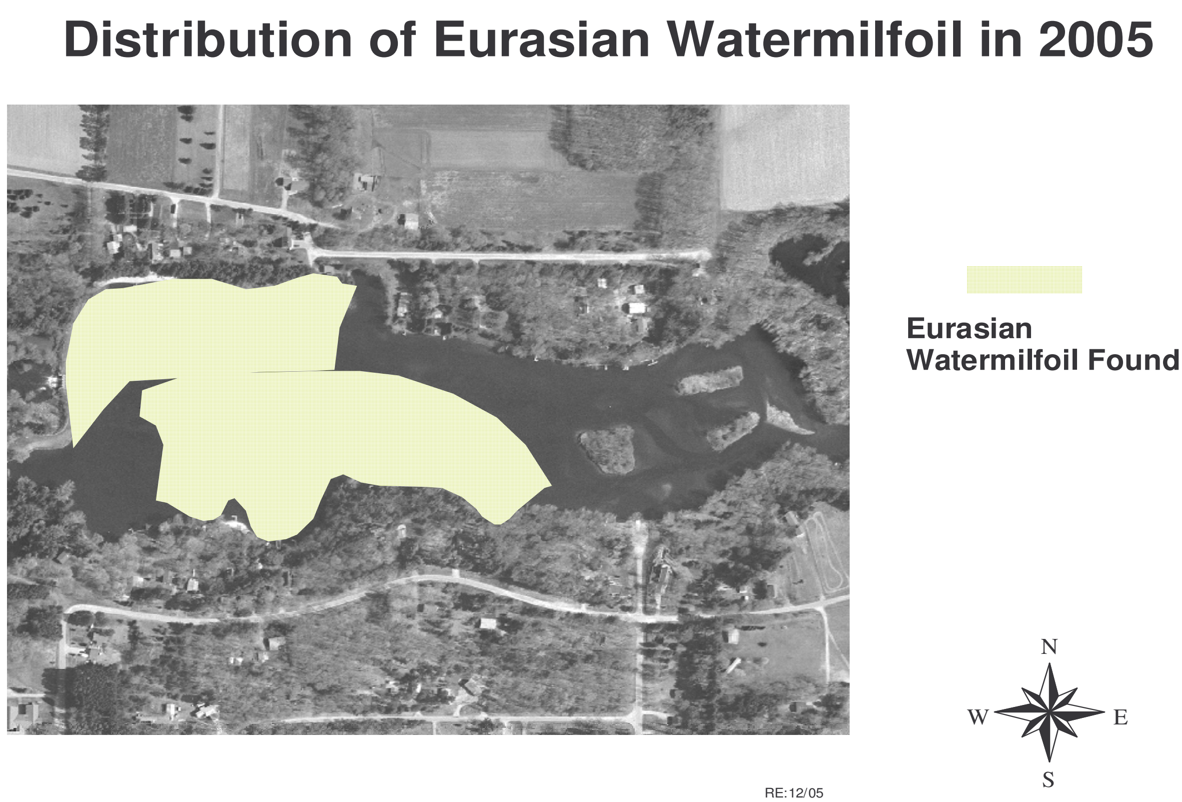
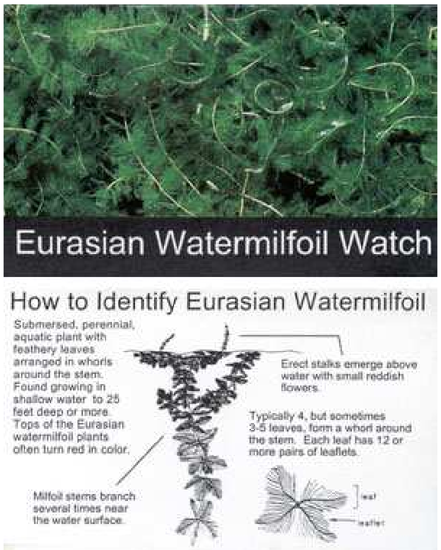


Figure 43: Most Common Invasive Aquatic Plant in Arkdale Lake



Myriophyllum spicatum
(Eurasian Watermilfoil)

Arkdale Lake has a recent history of one other very destructive, very difficult-to-control exotic species, *Orconecters rusticus* (Rusty Crayfish). Rusty crayfish feed on a variety of aquatic plants, benthic (bottom) invertebrates, crustaceans, detritus, fish eggs and small fish. They displace native crayfish by competition and by causing increased predation of the natives. They force native crayfish out of hiding in the day, making the native species more vulnerable to fish predation. Rusty crayfish are seldom preyed upon once they are mature, since they take a defensive "claws up" posture that discourages fish from eating them. Thus, rusties are not eaten as often as native species, increasing their survival rate. Rusty crayfish also eat at least two times more than the native crayfish do, thus outcompeting the natives for food and reducing the food availability for native species.

One of the most serious impacts of a rusty crayfish population is the destruction of aquatic plant beds. Studies have shown that their presence results in reduction in aquatic plant abundance and aquatic plant species diversity. They literally uproot the aquatic plants and eat much of the plant parts voraciously. In 2006, Arkdale Lake residents noticed that aquatic plant growth on the east of their lake—where many rusty crayfish were found—was nearly gone.

Such a reduction is very negative. Aquatic plants provide habitat for invertebrates on which fish & ducks feed, provide shelter for young fish, provide nesting substrate for some fish, provide cover for prey fish, and provide erosion control by dampening waves. Fewer aquatic plants may mean fewer fish in the water body. Anglers may find that as the lake's aquatic plant diversity decreases, some fish species start having trouble finding food, thus disrupting the food chain and causing many fish to decline in number or disappear entirely. A lake infested with rusties is also not comfortable for swimming due to the real danger of stepping on and/or getting pinched by the large claws.

This species is very difficult to control. Any chemical that would kill these crayfish would also decimate the native crayfish. At least two lakes in northern Wisconsin are trying a combination of aggressive trapping of adult rusty crayfish and importation of smallmouth bass to prey on the rusty babies. These efforts will be watched by the Arkdale Lake Association and Adams County Land & Water Conservation Department to determine if such an effort might work on Arkdale Lake.

Figure 44: Photos of Rusty Crayfish

Critical Habitat

Designation of critical habitat areas within lakes provides a holistic approach for assessing the ecosystem and for protecting those areas in and near a lake that are important for preserving the qualities of the lake. Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes.

Protection of critical habitat areas must include protecting the shore area plant community, often by buffers of native vegetation that absorb or filter nutrient & stormwater runoff, prevent shore erosion, maintain water temperature and provide important native habitat. Buffers can serve not only as habitats themselves, but may also provide corridors for species moving along the shore.

Besides protecting the landward shore areas, preserving the littoral (shallow) zone and its plant communities not only provides essential habitat for fish, wildlife, and the invertebrates that feed on them, but also provides further erosion protection and water quality protection.

Field work for a critical habitat area study was performed on May 31, 2006, on Arkdale Lake, Adams County. The study team included: Scot Ironside, DNR Fish Biologist; Deborah Konkel, DNR Aquatic Plant Specialist; Buzz Sorge, DNR Lake Manager; and Reesa Evans, Adams County Land & Water Conservation Department. Areas were identified visually, with GPS readings and digital photos providing additional information. Input was also gained from Terence Kafka, DNR Water Areas were identified visually, with GPS readings and digital photos providing additional information.

Critical Habitat Area AR1

This area extends along the entire northeast end of the lake and the eastern end of the north shore, with an average water depth of less than 2' in the most eastern end and of less than 3' along the north shore. Sediment includes muck, silt and mixtures thereof. 25% of the shore is wooded; 55% is native herbaceous cover and 20% is shrubs. Some woody cover is present for habitat. Human disturbance impact on this area is currently limited, perhaps partially due to the very shallow waters.

Figure 45: Various photos of AR1

Aquatic vegetation found at AR1 included six emergent plants, two free-floating plants and six submergent species. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. The free-floating species are used for food and cover by various fish and wildlife. Filamentous algae were also abundant here.

This area of some woody cover, emergent aquatic vegetation, submergent and a little floating vegetation provides limited spawning and nursery areas for many types of fish: largemouth bass; bluegill; pumpkinseed; yellow perch; crappie; and other panfish. All of these fish also feed and take cover in these areas. *Myriophyllum spicatum*, Eurasian Watermilfoil, has been found in Arkdale Lake in the past years. None was found at Site AR1.

Critical Habitat Areas--Arkdale Lake

RE:6/06

Figure 46: Critical Habitat Areas on Arkdale Lake

Critical Habitat Area AR2

This area extends along the 425’ of the south shoreline with an average water depth of less than 5’. Sediment includes muck, silt and mixtures thereof. 40% of the shore is wooded; 23% is native herbaceous cover and 35% is shrubs. Some woody cover is present for habitat. This area is a small section of currently undeveloped shore, with development present on both sides of it. Human disturbance impact on this particular area is currently limited.

Fishery in this area includes largemouth bass, bullheads and several types of panfish, including bluegills, pumpkinseed and crappie. Rusty crayfish were present in great numbers during the field review in May 2006. Geese and songbirds are known at this site, as are amphibians and reptiles.

Only one species of emergent aquatic vegetation found at AR2. Two types of rooted, floating-leaf aquatic species were present at this site, as well as three species of free-floating aquatic plants. Six submergent species were found, but no exotic invasive plant species. Filamentous algae were also abundant here.

Critical Habitat Recommendations

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove any fallen trees along the shoreline.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain any snag/cavity trees for nesting.
(6) Install nest boxes.
(7) Maintain or increase wildlife corridor.
(8) Maintain no-wake lake designation.
(9) Protect emergent vegetation.
(10) Seasonal control of Eurasian Watermilfoil with methods selective for control of exotics.
(11) Develop & implement control plan for invasive Rusty Crayfish.
(12) Minimize aquatic plant and shore plant removal to maximum 30’ wide viewing/access corridor and navigation purposes. Leave as much vegetation as possible to protect water quality and habitat.
(13) Use best management practices.
(14) No use of lawn products.
(15) No bank grading or grading of adjacent land.

(16) No pier placement, boat landings, development or other shoreline disturbance in the shore area of the wetland corridor.
(17) No pier construction or other activity except by permit using a case-by-case evaluation and only using light-penetrating materials.
(18) No installation of pea gravel or sand blankets.
(19) No bank restoration unless the erosion index scores moderate or high.
(20) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(21) Placement of swimming rafts or other recreational floating devices only by permit.
(22) Maintain aquatic vegetation buffer in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post exotic species information at public boat landing.

Figure 47: Photo of Arkdale Lake in Autumn*

***photo courtesy of Doug Wellumson**
Arkdale Lake Resident

FISHERY/WILDLIFE/ENDANGERED RESOURCES

WDNR fish stocking records for Arkdale Lake go back to 1935, when northern pike, bullheads and bass were put into the lake. In 1965, a break of the Arkdale Dam resulted in several hundred dead fish. An evaluation in 1971 determined that the lake was best suited for northern pike, largemouth bass and panfish. A 1995 WDNR survey of Arkdale Lake indicated that northern pike and white sucker were abundant. Yellow perch, black crappie and bluegills were common, but largemouth bass, walleye, spotted suck and pumpkinseed were scarce.

Recent reports from lake users express the belief the fishing has declined since the infestation by rusty crayfish. Aquatic plant growth at the eastern end of the lake has declined since that infestation as well. A plan for diminishing the impact of rusty crayfish needs to be developed by the Arkdale Lake Association.

Seen during the field survey were various types of waterfowl and songbirds. Frogs and salamanders are known, using the lakeshore for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well.

The Arkdale Lake watersheds are home to many endangered resources. Endangered natural communities found in these watersheds include floodplain forest, lake (shallow, hard, seepage), northern sedge meadow, northern wet forest, pine barrens and shrub-carr. Endangered, threatened or special concern plant species found in these watersheds are Crossleaf Milkwort, Engelmann Spikerush, Grassleaf Rush, One-Flowered Broomrape, Slim-stem Small-reedgrass, Whip Nutrush and Yellow Screwstem, Karner Blue Butterfly, Persius Dusky Wing Butterfly, and Sand Snaketail Dragonfly.

Scleria triglomerata
(Whip Nutrush)

Lycaeides Melissa samuelis
(Karner Blue Butterfly)

Figure 48: Photos of some of the species of concern in Arkdale Lake Watersheds

Erynnis persius
(Persius Dusky Wing)

Polygala cruciata
(Crossleaved Milkwort)

*information courtesy of Wisconsin Department of Natural Resources

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